Iron and Steel Engineer

J. F. KELLY, Editor

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COMING MEETINGS AND PAPERS

CHICAGO DISTRICT SECTION

Tuesday, February 21, 1928 — **Electric Power Club** — **30 North Dearborn St. Chicago, Ill.**

MID-WINTER SAFETY CONFERENCE

"EDUCATION AS A MEANS IN ACCIDENT PREVENTION," by John P. Eib, Safety Director, Illinois Steel Company, Joliet, Ill.

The author will outline the chief educational features that were instrumental in producing a record of 5,028,640 hours no lost time accidents at the Joliet Works of Illinois Steel Company, Joliet, Ill.

"ELECTRICAL SAFETY CIRCUITS, THEIR USES AND CONSTRUCTION," by W. M. Runyon, Engineer, Crouse Hinds Company, Syracuse, N. Y.

"CODES FOR USE IN HIGH TENSION PRACTICES," by C. L. Baker, Management's Representative, Bethlehem Steel Co., Johnstown, Pa.

PHILADELPHIA DISTRICT SECTION

Saturday, March 3rd, 1928 — **Engineers Club** — **Philadelphia, Penna.**

"RECENT DEVELOPMENTS AT SPARROWS POINT PLANT OF BETHLEHEM STEEL COMPANY, SPARROWS POINT, MD," by F. O. Schnure, Elec. Supt., Bethlehem Steel Company, Sparrows Point, Md.

Saturday, April 7th, 1928 — **Engineers Club** — **Philadelphia, Penna.**

GENERAL IDEAS AND DISCUSSIONS

"The Three F's of the Electrical Industry," by D. M. Petty, Electrical Supt., Bethlehem Steel Company, Bethlehem, Pa.

"Application of Across the Line Starters for Induction Motors," by P. T. Vanderwaart, Elec. Engr., New Jersey Zinc Co., Palmerton, Pa.

"Recuperators, With Special Reference to Those Used on Forge Furnaces," by A. E. Walden, of Wehr & Walden, Engrs., Baltimore, Md.

"Automatic Priming Pumps," by N. C. Bye, Mechanical Engineer, Henry Disston & Sons, Philadelphia, Pa.

"Air Conditioning Equipment," by W. H. Burr, Supt., Elec. Dept., Lukens Steel Company, Philadelphia, Pa.

PITTSBURGH DISTRICT SECTION

Saturday, March 3rd, 1928 — **Wm. Penn Hotel** — **Pittsburgh, Penna.**

"HIGH TENSION INSULATORS"

"Protecting From Flashover," by H. B. Vincent, Engr., R. Thomas & Sons Company, East Liverpool, Ohio.

"Mechanical Design," by G. M. Barrow, Engr., Westinghouse Electric & Mfg. Company, Derry, Pa.

"Effect of Dirt on High Voltage Insulators," by G. W. Lapp, Chief Engineer, Lapp Insulator Company, Le Roy, New York.

"Protection From Flashover" and "Overhead Ground Wires," by W. W. Lewis, General Electric Company, Schenectady, New York.

"Protection From Flashover," by K. A. Hawley, Engr., Locke Insulator Corporation, Baltimore, Md.

"Protection From Flashover," by A. O. Austin, Chief Engineer, Ohio Insulator Company and Chief Consulting Engr., Ohio Brass Company, Mansfield, Ohio.

Mechanical Design," by W. L. Stinson, Vice Pres., Jeffery Dewitt Insulator Co., Kenova, W. Va.

"The Application of Hardware to High Tension Insulators," by Engineers from West Penn Power Company and Duquesne Light Company.

"Exhibit of High Tension Insulators and Hardware," by the various manufacturers.

Exhibit open from 2:30 P. M. to 9:30 P. M. Technical Sessions 3:30 P. M. and 7:45 P. M. Dinner 6:30 P. M.

BIRMINGHAM DISTRICT SECTION

Saturday, March 31st, 1928

"The Invisible Relay in Vari-Time Control," by W. H. Williams, Vice President, Clark Controller Company, Cleveland, Ohio.

Saturday, April 28th, 1928

"Water Cooled Furnaces," Auspices of Combustion Engineering Division of A. I. & S. E. E.

EDITORIALS

1497 DRIVES IN STEEL MILLS HAVE BEEN ELECTRIFIED SINCE 1905. INDUSTRY SHOULD BE COMPLETELY ELECTRIFIED BY 1938. THE FOLLOWING TABLE INDICATES THE SPEED OF ELECTRIFICATION BY YEARS: RANGE OF MOTORS, 300 HP TO 9000 HP

Year	Number of Motors Purchased	Horse-power	Year	Number of Motors Purchased	Horse-power
1905	7	11900	1917	83	106425
1906	9	25640	1918	50	46650
1907	9	26600	1919	119	95650
1908	8	8050	1920	127	123620
1909	21	27150	1921	47	44350
1910	31	32500	1922	86	88605
1911	7	3100	1923	73	103150
1912	29	31700	1924	78	137700
1913	50	46100	1925	150	267485
1914	42	42775	1926	153	231660
1915	103	107280	1927	102	136050
1916	113	162460	1928	?	?

MIND VERSUS BRAWN

In the nineties, steel men were usually hailed as men of brawn. That was true in those days of hand mills when men in pits of fire struggled and toiled with brute force in shaping the red hot slabs into finished forms, rails, rods, pipe, sheets, beams and whatnot.

"Brawn" then—not "mind" was master and continued so until the invisible dominant force "electricity" called the mind and not the strength into play. With this power came what is now popularly termed "education in the steel plants" and so today intelligence and skill have taken the place of brawn.

The steel plants in the United States early recognized that in order to keep pace with the advancement and progress that was being made in their industry, highly specialized training was necessary for their employees.

This problem was met in various ways, one of which was the institution of night courses where their employees would receive special training. Many of the employees took advantage of this opportunity and today occupy positions of trust and responsibility.

However, there is still much to do in the industry in educating the employees in their respective capacities. The Association of Iron and Steel Electrical Engineers has in mind a co-operative plan whereby the employees of the electrical departments may better equip themselves for their daily tasks. To be successful, these plans must have the undivided support of the industry at large and the membership of the AI&SEE is invited to extend their assistance upon presentation of the educational program.

It has been our good fortune to have been successful in our every undertaking for the reason that in the end the tasks undertaken have ever been for the interest of the industry, and the education of man. With this naturally follows reduction in maintenance and operating costs.

So as to add one more success to our long string of victories, we are studying every angle of the question before its presentation to our members and we hope that when the time comes to voice your opinions and criticisms and offer your assistance, you will not be found wanting.

FUEL SAVINGS CONFERENCE

On Thursday, March 29th, 1928, the Combustion Engineering Section of the Association of Iron & Steel Electrical Engineers will hold their Annual Fuel Savings Conference at the Edgar Thomson Works of the Carnegie Steel Company, Braddock, Pa.

The conference will consist of an inspection trip and a technical session covering "Dry Quenching of Coke" and "Pulverized Coal Applications to Industrial Furnaces."

Mr. O. J. H. Hartsuff is General Superintendent of the Edgar Thomson Works of Carnegie Steel Company and Mr. L. C. Edgar is Chief Engineer of the plant.

As the Edgar Thomson plant is one of the most modern in the country, it will be of educational interest to the Combustion Engineers of the Steel Industry, many of whom will travel from all parts of the United States to participate in both the inspection and technical sessions.

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Metal Air Heater For Industrial Furnaces*

By WALDEMAR DYRSSEN†

THE idea of heating combustion air for metallurgical heating furnaces by the use of heat in the waste gases leaving the furnaces is very old. The saving in fuel which can be obtained by the use of preheated air is considerable, and this saving increases rapidly as the temperature required in the furnace is increased. It has also been thoroughly proven, both in theory and in practice, that the saving in fuel is considerably higher than the actual heat introduced into the furnace by the preheated air.

The fuel saving that can be obtained by the use of preheated air is shown in Fig. 1. At the bottom of this figure are given the temperatures at which the waste gases leave the furnace, and below them are given corresponding temperatures to which the air is preheated. With these temperature conditions the fuel saving that is obtained is indicated by the curve in the figure. For example, the saving in fuel is approximately 14% when the temperatures of the waste gases leaving the furnace are 1000° F. An increased saving is obtained at higher temperatures

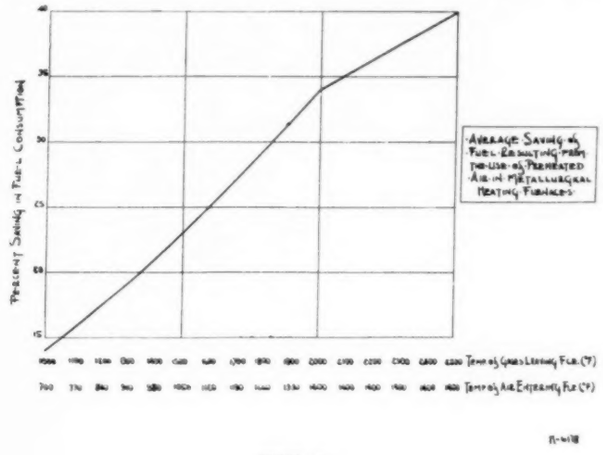


FIG. 1.

of the gases so that the saving is about 40% at a temperature of 2500° F. Particular attention should be given to the temperature of the preheated air in this figure. It can be seen that up to a gas temperature of 2000° it has been assumed that the air temperature is 70% of the gas temperature, but at temperatures above 2000° of the gases the air temperature has been assumed to be constant at 1400° F. The air temperatures given in the figure have been assumed because these temperatures can be obtained in metallic air heaters, which is the particular subject of this paper.

The savings indicated in Fig. 1 apply with close approximation to all ordinary fuels, such as oil, tar, natural gas, city gas, coke oven gas, powdered coal, hot producer gas, etc. For very lean fuels, such as cold clean producer gas and especially for blast furnace gas, the saving in fuel is considerably higher at high temperatures. In fact, for furnace temperatures above about 2000° F., these lean fuels cannot be successfully used without the use of preheated air as their combustion temperature with cold air is too low. The savings indicated in the figure are based on an excess quantity of air above that required for combustion of about 10%, and if more excess air than this is used for combustion the saving in fuel will be still higher. For air temperatures less than that given in the figure the saving in fuel will, of course, be about correspondingly less than given.

Important as the fuel saving is, there are, however, other effects in connection with the use of preheated air which may in some instances be more important than the fuel saving. We know that the combustion is quickened by the use of preheated combustion air, a condition which results in a shorter and higher temperature flame and in a more complete combustion with a smaller amount of excess air. This effect of preheated air can be used to great advantage if the furnaces are designed for these conditions. The use of preheated air is also advantageous in cases where it is desired to run the furnace with a so-called reducing atmosphere, that is without the use of excess combustion air. There are also a great many furnaces in existence where preheated air will make a higher production possible, due to the fact that the increased flame temperature gives a higher rate of heat transfer without the necessity of forcing the furnace. The proper introduction, mixing and proportioning of air and fuel, is of course extremely important and must always be considered carefully in all installations. This is, however, outside the scope of this paper.

There are several methods in use for heating air in metallurgical furnaces. We are all acquainted with the ordinary regenerative chambers, or so-called checker chambers. They are used with all open hearth furnaces and with a large number of high temperature heating furnaces, and for obtaining the very highest temperatures the checker chambers are without rivals. Due, however, to their large bulk and expensive installation their particular field is limited, and it is the author's opinion that the modern air heaters will limit this field still further.

We have also the so-called tile recuperators. It is the author's opinion that the improvements that are being made in the use of metallic recuperators will render tile construction obsolete in the future. Their large volume and their high installation cost makes them uneconomical as compared to the modern metal air heaters, which are much superior to the tile recuperators from the standpoint of repairs as well. It is also impossible to obtain preheated air under pressure with a tile recuperator, and it is necessary to have the air under pressure and under perfect control at all times in order to obtain full advantage of preheated air. A metallic heater which can withstand the temperatures and the pressure required without deterioration or leakage should therefore be the choice of both the engineer and the operator.

Presented Nov. 5, 1927, A. I. & S. E. E., Engrs. Club, Philadelphia, Pa.

†Chief Engr., Furnace Equipment Dept., Blaw Knox Co., Pittsburgh, Pa.

Metallic air heaters have been in use for at least one hundred years. Until very recently the only material that was used was cast iron. Cast iron air heaters had been very highly developed, and some quite remarkable results had been obtained by the use of them. Attention should be particularly called to the early air heaters that were developed for heating the blast for blast furnaces before the introduction of the blast furnace stove. Such cast iron heaters were quite in general use at one time in this country and blast temperatures up to 900° F. could be obtained through their use. This method of heating the blast is still extensively used on charcoal

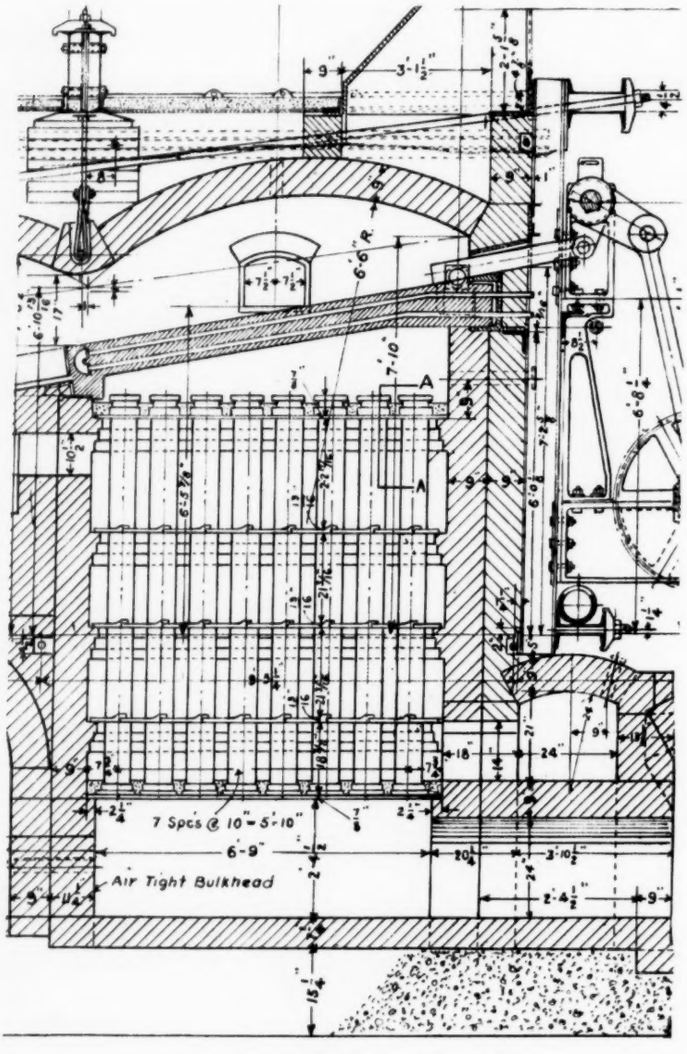


FIG. 2.

blast furnaces, in Sweden and Russia for instance. The heater mostly in use for this purpose in the former country employs U-shaped hollow castings, about nine to ten feet long. These castings rest on and are joined to cast iron boxes beneath them. There are two parallel boxes and the U-shaped castings lean against each other. All joints are covered with brickwork. The author has seen such pipes warp and bend six to twelve inches and grow in length three to four inches without serious leakage taking place, even at a pressure of two to three pounds per square inch.

Cast iron in the form of pipes arranged in the path of the gases leaving the furnace is and has been very extensively used for heating furnaces also. There are a great variety of such constructions, many of which are so-called "home-made." A popular arrangement for small and medium size furnaces is a construction employing horizontal pipes with the elbows and joints, connecting the pipes, placed outside the path of the hot gases, and with the air passing through the pipes. For high temperatures the pipes in some instances have been covered with refractory materials so as to protect the cast iron from excessive heating. This latter method, however, reduces the efficiency of the heater to such an extent that it should not be considered. A popular cast iron heater is the Morgan Recuperator shown in Fig. 2. The figure shows the heater applied to a continuous heating furnace. It consists of a large number of vertical cast iron pipes; the waste gases from the furnace pass downward through the inside of

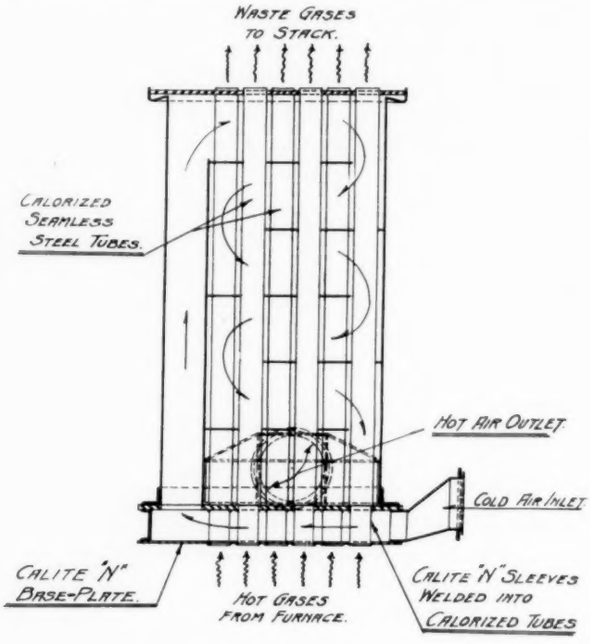

WASTE GASES TO STACK.
CALORIZED SEAMLESS STEEL TUBES.
HOT AIR OUTLET.
COLD AIR INLET.
CALITE "N" BASE-PLATE.
HOT GASES FROM FURNACE.
CALITE "N" SLEEVES WELDED INTO CALORIZED TUBES

FIG. 3.

these pipes, while the air to be heated is made to pass upward, by the use of baffles, in a zigzag horizontal path across the tubes. Temperatures as high as 800° F. can be reached in these heaters, although the air temperature actually attained is usually considerably below this figure.

Cast iron has, however, properties which limit its use to comparatively low temperatures. At red heat or at temperature above or about 1000° F. cast iron grows when exposed for long periods of time. At the same time that it grows or increases in volume cast iron will warp and change its shape. Cast iron is also easily cracked at high temperatures and it will also in time be destroyed by oxidation. It is evident therefore that if cast iron pipes, or other hollow castings, are used where the temperatures of gases are over or about 1200° F., air heaters built of such material will soon leak to such an extent that they will accomplish very little and they will be useless until again repaired, a procedure which is usually both difficult and costly.

In metallurgical furnaces the operating conditions are usually extremely variable and a heater must, of course, be constructed so as to withstand the extreme temperature peaks that may occur. We cannot, for instance, depend upon the assumption that complete combustion is obtained at all times in the furnace proper. Secondary combustion of the gases leaving the furnace must be expected to occur occasionally, resulting in high temperatures in the heater. The above is therefore a serious limiting factor for the use of cast iron air heaters in industrial furnaces.

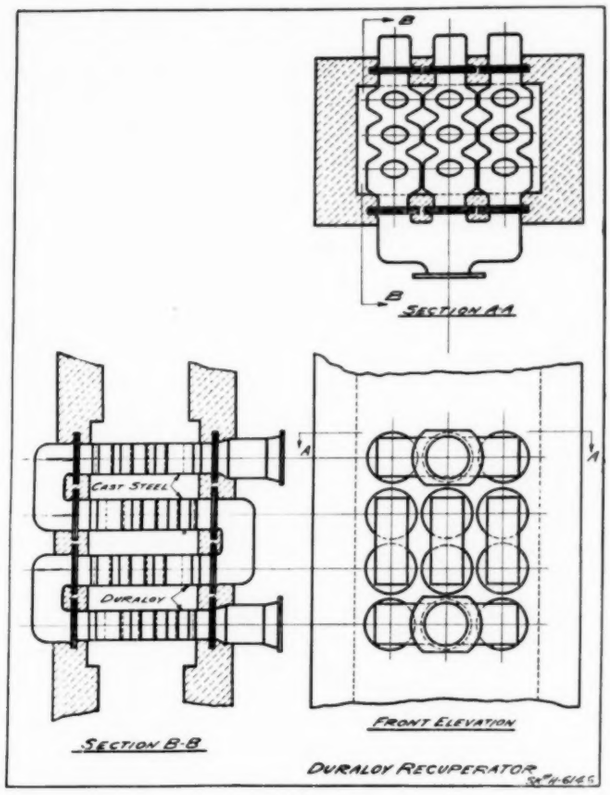


FIG. 4.

The rapid development of heat resisting steels during recent years has, however, very much enlarged the field for the application of metallic air heaters. The steels referred to are the so-called high chromium steels with chromium content varying from twelve to thirty per cent. Some of these steels contain large quantities of nickel also, and there are some steels that contain silicon and other alloys in addition to chromium. Such steels can now be obtained in ordinary rolled bars, pipes and sheets, as well as in the form of castings. The price of such alloy steels is still very high, but these prices do not exclude them from use in air heaters for metallurgical furnaces. The heat resisting properties of such steels are largely dependent upon the chromium content. For instance, a steel containing about 12% chromium can successfully withstand a temperature of 1300° F., while a steel containing 25 to 30% chromium can withstand a temperature up to 2100° F. We have still much to learn about these various heat resisting steels, their properties at high temperatures and their proper application under various conditions, but we know sufficient, however, to apply them successfully if proper discretion is used. Prospective users ought therefore be warned against extravagant claims made for these steels.

These steels are also much superior to ordinary steels and cast iron in mechanical properties at high temperatures, and even at a temperature as high as 1800° F. there is a perceptible, even if small, amount of strength left in them. Many of these high chromium steels, however, get extremely brittle when exposed to high temperatures for any length of time, and this fact must be recognized when applying

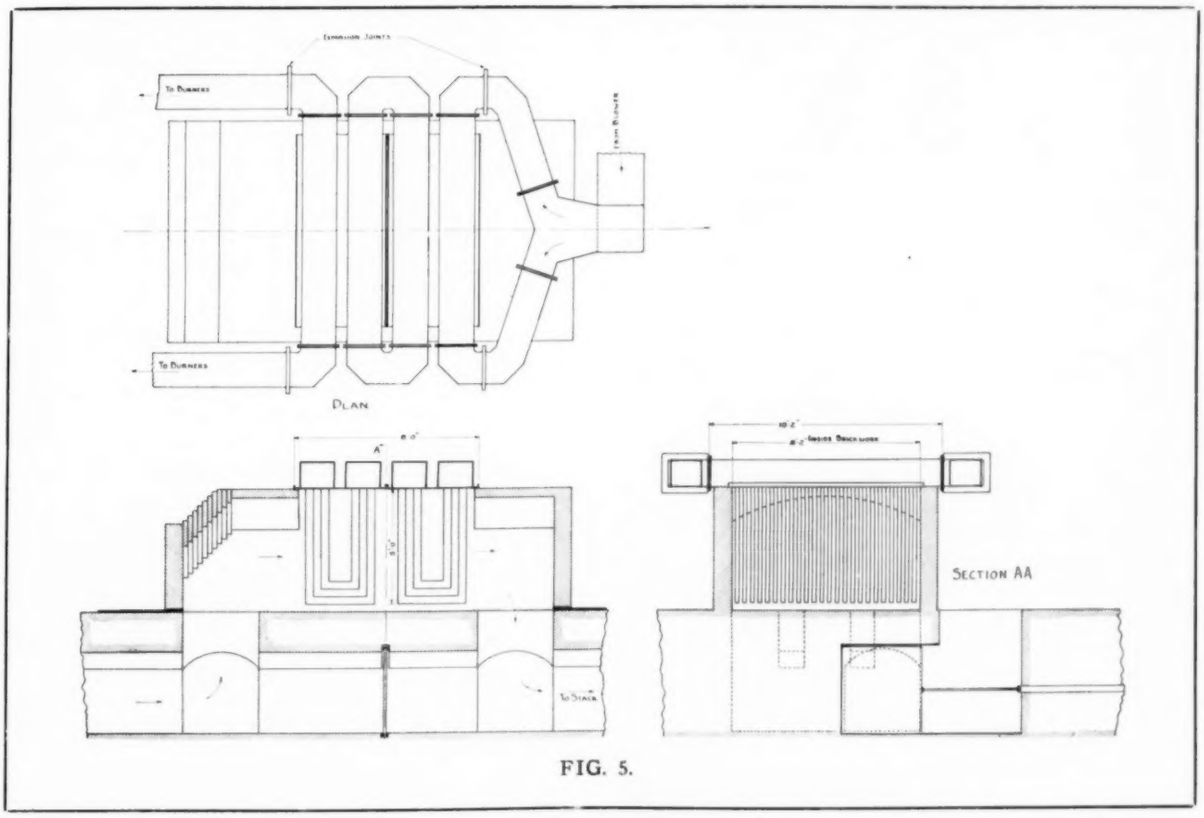


FIG. 5.

these steels to high temperature air heaters. It should also be pointed out that air or oxygen is not the only agent of deterioration of steels at high temperatures. There are other elements, such as sulphur, which may also attack the so-called heat resisting steels. This is particularly the case in certain steels that contain nickel, and care should be taken in applying such steels in cases where the gases contain considerable quantities of sulphur gases.

Methods have also been worked out for coating ordinary steel pipes, steel sheets, etc., with a layer that is resistant to heat and oxidation. Such coatings are, for instance, aluminum oxide and chromium.

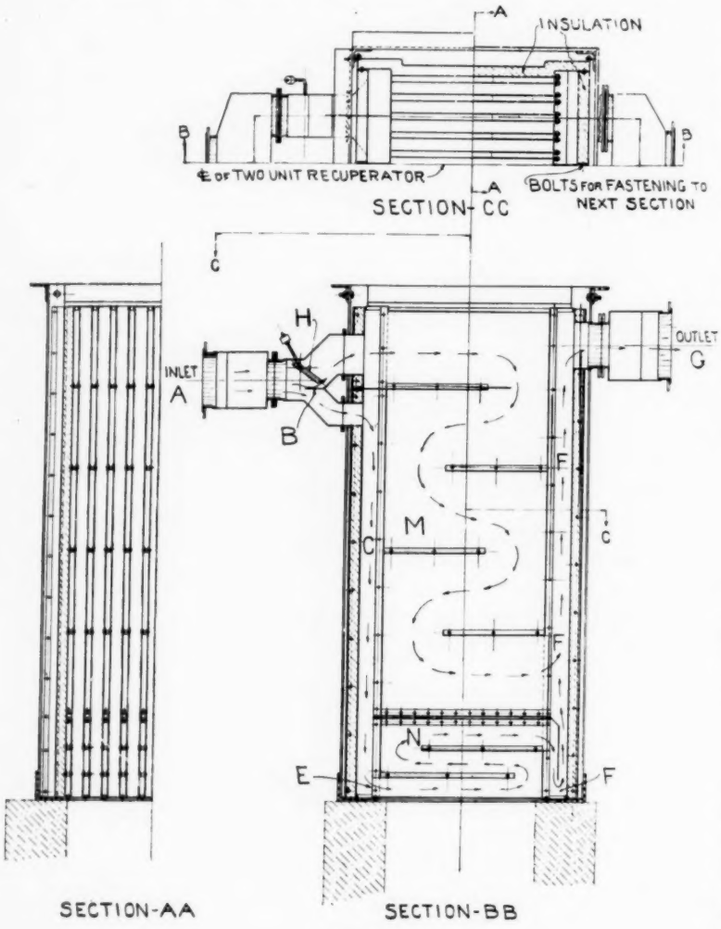


FIG. 6.

All these improvements in the heat resisting metals have increased the use of metallic air heaters very much in recent years, and it seems certain that there is going to be a rapid development of metallic air heaters for high temperatures.

There are certain fundamental points in construction and operation of metal air heaters that are worth while to enumerate:

1. They should be constructed of material that will resist oxidation for a long time at the highest temperature encountered.

2. In application it should be borne in mind that oxygen is not the only agent that will deteriorate heat resisting steels; there are often sulphur gases and other deteriorating agents present in gases from industrial furnaces.

3. Where the construction depends upon the heat resisting steels as division walls between air and gases, the steel should be of such quality that it will not become brittle when exposed to high temperatures for long periods of time.

4. The expansion of the steel elements is great and extremely variable in different parts of the heater. In this respect air heaters are in direct contrast to boilers, for instance. The heating elements should, therefore, be free to expand in any and all directions, and the heater should also be so constructed that a certain amount of warping of the elements does not injure the heater.

5. In heaters where welds and riveted joints are employed, such joints must be protected as much as possible and they must be so placed that expansion and warping of the elements do not break up these joints.

6. In heaters made of different materials joined together, it must be remembered that the expansion coefficient of the different steels employed may be different for each material employed.

7. The heater should be constructed so as to take care of a reasonable pressure difference between air and gases at the highest temperature encountered.

8. The heaters should be economical in weight and space and they should have a maximum of heating surface per unit of weight and cost.

9. The heaters must be so installed that their destruction or damage will not occur in case air ceases to flow through them.

10. All parts of the heater must be easily accessible for cleaning and inspection.

There are several metallic air heaters on the market using heat resisting steel. Some of these are quite well known and a short description of them will therefore suffice. It is not claimed that this list is complete, but it gives an idea of a few representative metallic heaters.

"CALCO" RECUPERATOR

This heater, as shown in Fig. 3, consists of vertical tubes. The hot gases pass into the tubes at the bottom and flow upward through the tubes and the cooled gases are discharged into the stack. The cold air is introduced at the bottom around the tubes, then ascends through a jacket space surrounding the recuperator and flows down in a zigzag path across the tubes, as shown in the figure. The flow principle of the gases and air in the heater is therefore a combination of parallel and counterflow, with the latter predominating. The lower ends of the tubes, as well as the base plate, are made of high nickel chromium steel, so-called "Nichrome" Steel; and all other parts of the heater which are exposed to high temperatures are made of so-called calorized (aluminum coated) steel. Expansion joints are provided at the top of the heater.

The advantages claimed for this recuperator are efficient heat transfer; protection of the hot ends of the tubes by circulation of cold air around them; practically leak-proof construction due to the use of welded joints; compactness, and almost complete elimination of heat loss by radiation from the walls, due to the air-jacketing feature. These heaters are built in a number of sizes and are applied to both small and larger furnaces.

DURALOY RECUPERATOR

Fig. 4 shows the latest type of this recuperator as made for smaller furnaces. The recuperator in this design is built up of a number of hollow castings made of high chromium (so-called "Duraloy") steel. These castings are connected together by means of other hollow steel castings, and all joints are embedded in the brick wall so that they are not directly exposed to the hot waste gasses. The castings are cored out so as to obtain as large a heating surface as possible.

The Duraloy Company also makes, for larger furnaces, a recuperator of the hanging-loop type. Such an installation is shown in Fig. 5. In this heater the gases flow horizontally across the tubes and the air passes through the tubes, which are made in the form of "U's" hanging from headers placed on top of the waste gas flue. The advantages claimed for this recuperator are high rate of heat transfer; freedom of expansion together with flexibility of tube sides, reducing the possibility of cracking; leakproof construction, all joints being welded; and durability, due to the heat-resisting nature of the material used.

MANTLE RECUPERATORS

Fig. 6 shows this recuperator. It is a metallic flat-plate type recuperator, in which the waste gases pass upward in thin streams. Part of the air passes at all times across the lower ends of the separating plates, in order to prevent overheating where the hottest gases strike them. The remainder of the air, the volume of which is regulated by a damper in the inlet, passes downward and across the plates, leaves near the bottom, and passes upward to the outlet near the top. The plates are made of high chromium steel. All joints are on the air side, not exposed to the hot gases, and are both riveted and welded.

The advantages claimed for this recuperator are freedom of expansion, freedom from leaks, compactness, accessibility for cleaning the surfaces, and high rate of heat transmission. The recuperator is self-contained, and does not require a brick setting.

These heaters are all of the so-called stack-type, that is they are usually placed on top of the furnaces; but they may also be placed under the furnaces in the stack flue. In all cases, however, the stack pulls the gases through the heaters, and as they offer considerable resistance to the flow of gases, care should be taken that the furnaces can be properly regulated by the stack damper. In all such installations it is very important that adequate protection is provided, so that the heaters are not destroyed in the case of air ceasing to flow through the heater.

BLAW-KNOX REGENERATIVE AIR HEATER

This air heater has been developed during the last two and one-half years, and it has proved itself efficient and practical even for extremely high temperatures. This heater is very different in construction and operation as compared to the heaters just mentioned, and being of comparatively recent development in air heaters, it is not so well known. It may, therefore, be of interest to the members of our association to know a little more in detail about this heater.

The heater consists in its simplest form of three chambers in which the heating elements, consisting of steel sheets, are arranged vertically. These steel sheets are spaced a certain distance apart so that all the surfaces of the sheets are exposed to the flow of the gases and air. The chambers are provided with valves on the top and bottom, and by opening and closing these valves the flow of the air and gases is regulated through the chambers.

The construction of this heater is illustrated in Figure 7. The heating elements in each chamber are for a short period of time exposed to the flow of hot gases, and during this period heat is absorbed from the hot gases by the steel sheets. This period of heat absorption is followed by a period in which air is

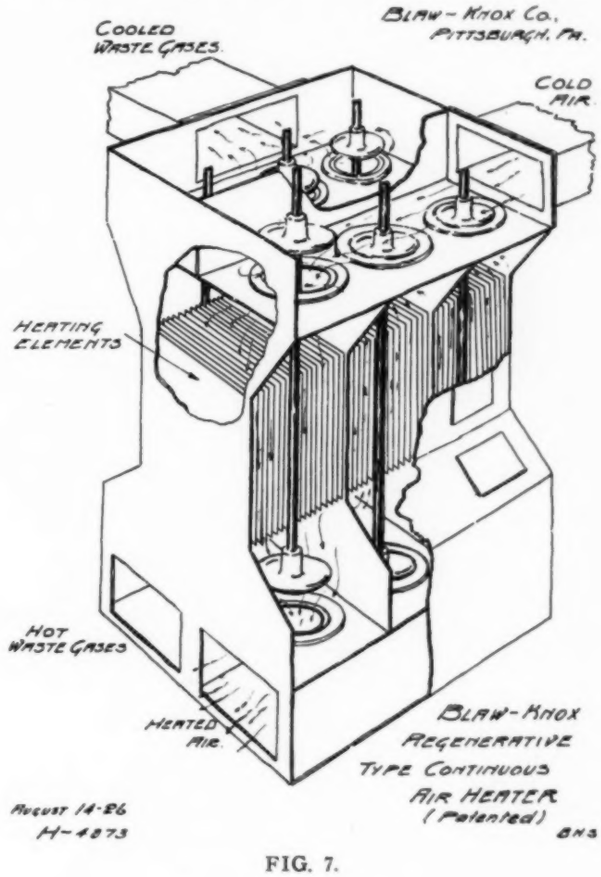
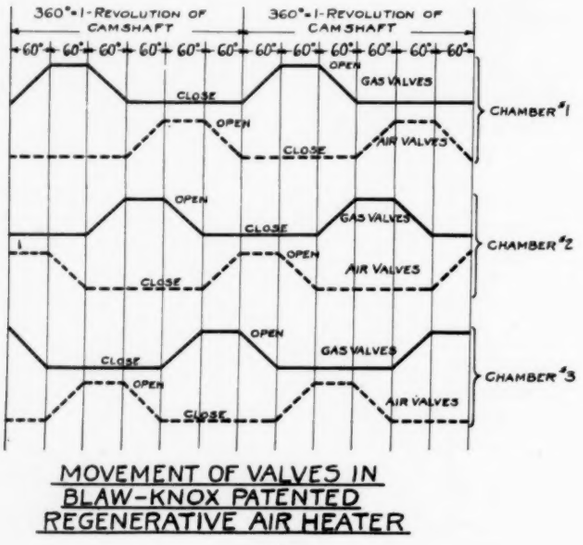


FIG. 7.

made to flow through the chambers in the opposite direction from that of the gases and the heat is given up by the steel sheets to the air. The principle of the heat transfer is therefore regenerative, but the periods are very short as compared to the heat regeneration which occurs in the so-called checker chambers in open hearth furnaces, or in blast furnace stoves. The length of the periods, in fact, is only one to one and one-half minutes, and the total time of reversal two to three minutes. By the use of such short periods it has been possible to reduce the amount of metal in the sheets to a minimum and the actual variation in temperatures of the sheets is only about 50°F. The reversal of the flow of air and gases is automatically accomplished by means of a continuously rotated cam shaft placed on the top of the heater.

A diagram of the valve movement is shown in Figure 8 and it can be seen that the actual raising and lowering of the valves takes place during a 60° turn of the cam shaft. There is therefore no shock in connection with the movement of the valves. It can also be seen from the diagram that there is always an opening corresponding to one valve for gases and one for air, so that there is no interruption or variation in the flow of the air and gases through the heater as a whole. The heater is therefore continuous in its action. The gas and air move through the heater according to the counterflow principle, which results in high efficiency and high temperature of air.



MOVEMENT OF VALVES IN BLAW-KNOX PATENTED REGENERATIVE AIR HEATER

FIG. 8.

The principal advantages of this heater are as follows:

1. A very large heating surface is provided within a small space.
2. An economical use of heat resisting alloy steel can be made.
3. Since there are no welded or riveted joints in connection with the heating elements, they are free to expand in all directions.
4. Since the heating elements serve only as transmitting media and not as division walls between air and gases, leakage is limited to the tightness of the chambers, and this leakage is therefore negligible even after long period of service.
5. The heating elements are easily cleaned without interruption of operation.
6. Deposits of dirt and soot do not affect the efficiency of the heater since heat transfer does not depend upon conduction.
7. The heater is adapted to air pressures as high as 16 ounces with practically no leakage.
8. The heater does not depend on stack draft for drawing the gases through the heater, and only the amount of waste gases required for heating the air is used in the heater. The draft required on the furnace is therefore regulated as usual with a stack damper.

An actual installation of such a heater is shown in Figue 9. This installation is made in connection with a glass tank, but it is typical of any installation in connection with an industrial furnace. In referring to this figure it can be seen that a fraction of the waste gases from the furnace flow in an underground flue to the bottom of the heater, and after passing through the various chambers in the heater the cooled gases are discharged to the stack by means of an exhauster. The air is blown in by a fan at the top of the heater, and after passing through the various chambers the hot air is discharged from the heater at the bottom and is led in an underground flue to the burners of the furnace.

The materials used in this heater are of four grades; 25% to 30% chromium steel is used in all lower valves, valve seats and valve stems, and also in the bottom sections of the steel sheets, while 15% chromium steel is used in the middle section of the sheets. The upper section of the sheets, where

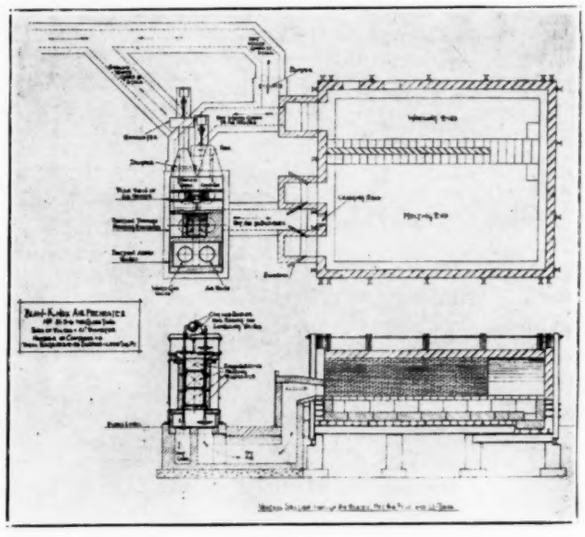


FIG. 9.

temperatures are comparatively low, is made of ordinary steel sheets. The valves and valve seats on top of the heater are made of cast iron. The grade of materials best suited for the temperatures that exist in the various parts of the heater is therefore used. This heater has been in service about 15 months and no deterioration of any part of the heater has been noticed. The average results obtained from this heater are shown in the table herewith.

Blaw-Knox Patented Regenerative Air Heater Installed on Direct Fired Continuous 35-ton Glass Tank (so-called U-Tank)

General Information	
Total Regenerative Heating Surface	5960 sq. ft.
Surface of 25 to 30% Chromium Sheets	1880 sq. ft.
Surface of 15% Chromium Sheets	1940 sq. ft.
Surface of ordinary Steel Sheets	2140 sq. ft.
Thickness of sheets for Heating Elements	1/16"
Number of Chambers	3
Size of all Valves	21 inches in diameter
Material in Lower Valves, Seats — Stems	30% Chromium Steel
Size of Motor for Operating Valves	½ H. P.
Time of one complete cycle of reversals	2 min. 50 sec.
Thickness of all Brick Lining	9" minimum

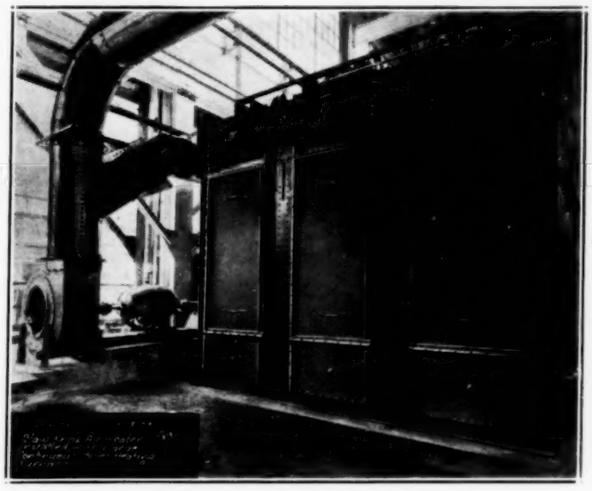


FIG. 10.

Average Operating Conditions

Start of Operation	July 15th, 1926
Fuel Used	Natural Gas
Fuel Consumption	11,000 to 13,000 cu. ft. per hr.
Combustion Air required	10,000 to 12,000 pounds per hr.
Temperature in Melting Chamber	2500 to 2600° F.
Temperature in Refining Chamber	2100 to 2200° F.
Temperature of Gases leaving Furnace	About 2000° F.
Temperature of Gases entering Air Heater	1600 to 1700° F.
Temperature of Gases leaving Air Heater	600 to 650° F.
Temperature of Air entering Air Heater	About 175° F.
Temperature of Air entering Burner Ports	1250 to 1350° F
Pressure Drop for Air in Air Heater	1 to 1.5 inches water
Draft Loss for Gases in Air Heater	1.5 to 2 inches water

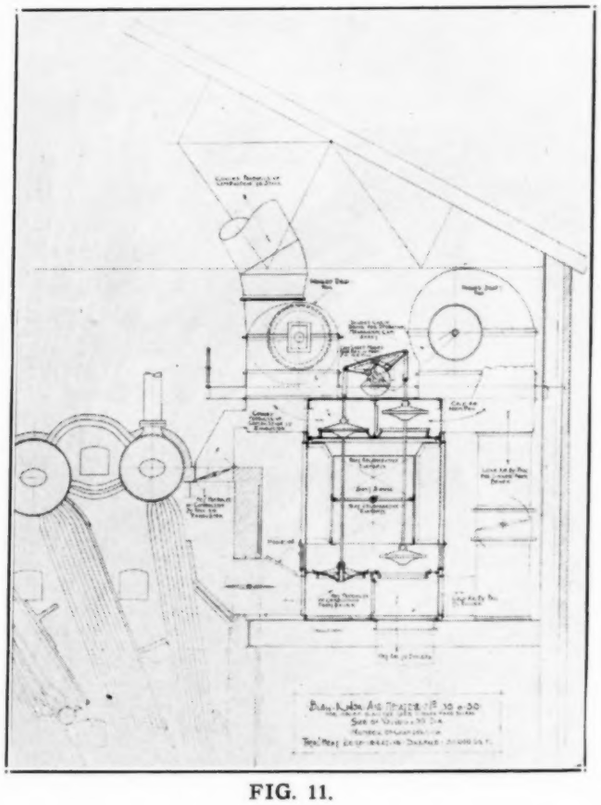


FIG. 11.

At times air temperatures as high as 1500° F. have been obtained and the heater is built to withstand a waste gas temperatures of 2000°F. It has been found necessary to clean the heater at intervals of about one and one-half to two and one-half months. This cleaning is easily accomplished within a very short time without any interruption of operation.

Figure 10 shows a large heater with 10,000 square feet of heating surface installed on a continuous heating furnace fired with raw producer gas. In this installation the fan and the exhauster are driven by the same motor and the air required is regulated by the speed of the motor which, of course, also regulates at the same time the amount of gases passing through the heater. It is also evident that if the fan is stopped the flow of the gases through the heater ceases at the same time, so that no undue heating can take place in the heater if the power fails, or if the air is shut off.

Due to the nature of the construction, the heater is especially applicable to large furnaces where large quantities of air are to be heated. The smallest furnace to which the heater has been applied is a furnace burning about four million B.T.U's. per hour, and the most suitable range is with furnaces burning from eight to fifty million or more B.T.U's. per hour. This range includes most metallurgical heating furnaces in steel mills, but does not cover small heating furnaces in manufacturing plants.

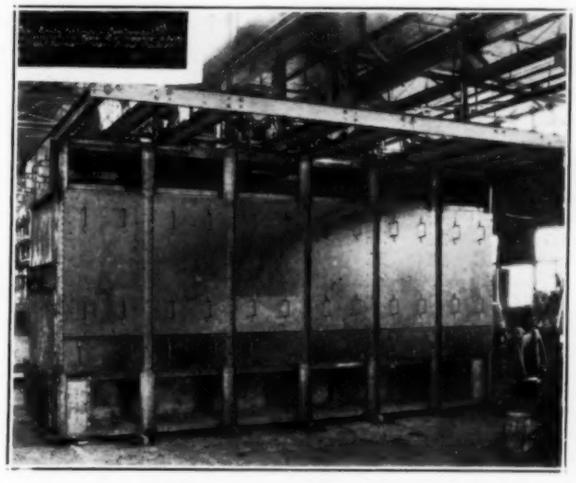


FIG. 12.

Assuming that a suitable metallic air heater installation can be made, one should, however, study his particular problem and attempt to determine the practicability of such an installation from an economical standpoint. It is evident that it may not pay to install an air heater in every case, but the many factors entering into such economical considerations make it impossible to lay down any definite rules or formulas which might govern the prospective use. The following are among the principal conditions which favor the installation of air heaters:

1. A high cost of fuel.
2. A fuel of low heating value.
3. Continuous operation of the furnace.

4. Furnaces of large capacity.
5. Furnaces operating at high temperatures.
6. Low rate of production for a given furnace.

It is the author's opinion that, except in extreme cases, the installation of metallic air heaters for industrial furnaces will pay the owner from 100 to 300 per cent on his investment. With the increasing fuel cost which we are now facing, with the increasing demand for better and more efficient furnace operating conditions, and with the increasing demand for over-all plant economy, the time is rapidly approaching the point when the installation of metallic air heaters will be more the rule rather than the exception.

The Chairman has advised me that there are quite a number present here tonight who are also interested in the application of air heaters to boilers. This is not exactly inside the scope of the paper just read, but I will be glad indeed to give some illustrations of the application of the Blaw-Knox Regenerative Air Heater to Boilers.

Fig. 11 shows a large heater applied to a 1100 B.H.P. blast furnace gas and stoker fired boiler. Five such installations have been made, but actually operating results cannot be given at this time because the boilers are not in operation yet. Each of these heaters has a total heating surface of 30,000 square feet, and arranged in six chambers. In this heater the automatic valve operation is such that there is always an opening corresponding to three chambers for the waste gases, and corresponding to two chambers for air. In this figure it can be seen that the waste gases leave the boiler near the top of the rear side and pass through a short flue into the bottom of the heater. From the bottom of the heater the gases pass upward through the various chambers which contain the steel sheets. The cooled gases leave the heater at the top and pass through a short flue connection to an induced draft fan placed on top of the heater.

The induced draft fan discharges the gas directly into the stack. The forced draft fan is also placed on top of the heater, and the air is blown into the top of the heater and passes downward through the various chambers where it is heated by coming in contact with the steel sheets. The hot air passes out from the heater in the bottom and is conducted through insulated flues to the combustion chamber of the boiler.

Fig. 12 shows an external view of such a heater, mounted in our shops before shipment.

The Blaw-Knox Company has also in the course of manufacture three very large air heaters, each with a heating surface of 50,000 square feet, for three 2500 H.P. Boilers.

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*Outdoor Substations**

By R. E. ANDERSON†

IT is a far cry from the rickety, hazardous wood pole structures, mounting a few built-by-guess switches, choke coils, etc., and known but a few brief years ago to the electrical industry as an outdoor sub-station, to the modern structures and preproven equipment constituting the nerve centers of modern super-power systems.

It is not my wish or intention to dwell on details, or indulge in lengthy discussion this evening, but merely to touch on the essentials of modern substation construction.

Steel Structures

As the foundation of today's office building is deserving of the most painstaking investigation and study, so the supporting structure of the modern outdoor sub-station should receive careful study and consideration. Aside from personal preference, the matter of spans over equipment, and mechanical loading will largely determine the choice between a solid section structure and one made up of latticed columns and girders. In either case the structure must be designed to withstand the loads imposed by the elements, uplift due to the pull of the conductors—even assuming breaking of all conductors on one side, in the case of a balanced loading resulting from conductors pulling in opposite directions from the station, it must provide ample electrical clearances and, withall, present a sightly appearance even to the eye of the layman.

*Presented before Chicago Section, November 15, 1927.

†Acting Chief Engineer, Delta-Star Electric Co., Chicago, Ill.

Busses

The busses may best be of the strained type—of stranded copper or aluminum, as is apt to be the case in long span stations of the latticed column and girder type of structure, or—due to complicated electrical layout or other imposed conditions—they may best be of the rigid type of rectangular copper bars or copper wire or tubing carried on rigid insulating supports. In the case of rigid busses, care should be taken to see that the connections between equipment mounted on the structure and that which is placed on the independent foundations are sufficiently flexible to avoid breakage due to vibration. Care should be exercised, in the case of rigid busses, to provide supports at amply frequent intervals, in order to guard against sagging, as well as distortion due to stresses set up by short circuits. The tendency toward making long unsupported bends should also be carefully avoided.

Switching Equipment

In the case of air break switches, the choice may be said to lie broadly, between the horizontal double break type with its manifest advantages in load breaking characteristics, simplicity of construction and positive action and the various forms available in the vertical break type. It is true, of course, that the space factor may frequently influence the choice in this matter, but careful consideration of operating characteristics should, in the final analysis, determine the choice.

In the matter of disconnects for oil circuit breakers, lightning arresters, etc., the choice lies between the single pole switches operated individually by hook stock from the ground, and various types of gang operated switches which can be controlled from a remote point. At first thought the single pole hook stick operated switch possesses advantages as to first cost and, while this may be the case in low

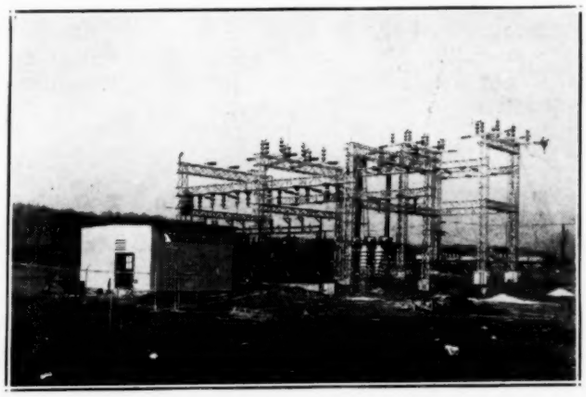

FIG. 1—110,000 Volt Substation on Super-Power System.

voltage equipment, this type of switch may even be disadvantageous in this respect in the higher voltage installations, due to the greater dimensions necessary in the steel structure, to provide operating space. From a safety standpoint there can be little, if any, question of the gang operated disconnect. The many forms and combinations in which it is available also make its use highly advantageous.

Gang operated switch, both "air break" and "disconnecting" types, should be provided with self aligning contacts (full floating type), and these contacts should be of a type which is fully closed (that

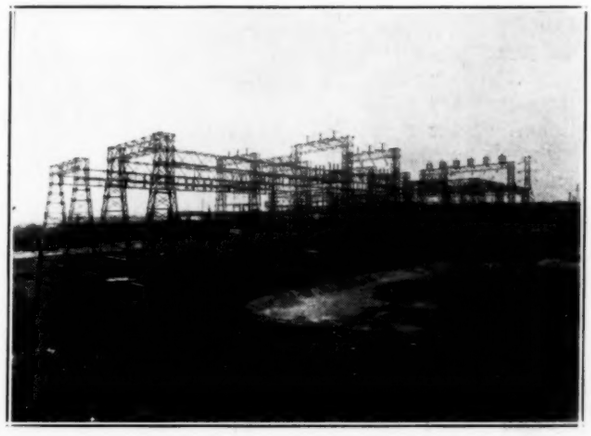

FIG. 2—132,000 Volt Substation at Waukegan, Ill.

is tight together) when the switch is in open position. This latter point is particularly important in the case of air break switches connected so as to bridge across an oil circuit break, as it is reasonable to expect that these switches will remain in the open positin for long periods, and a form of contact which gaps open under this condition is always questionable when the time comes to close the switch.

To those of you who have ever found it necessary to go out on the system and open an air break switch under sleet and ice conditions, it is superfluous to say that these switches should invariably possess a sub-movement, or form of horizontal play in the blade which will enable you to break the ice deposit before actually opening the switch.

Generally speaking, switches which are to be called upon to open load should be mounted in a horizontal position and, except in cases of absolute necessity, should not be mounted beneath other equipment; the theory being that the arcs found on the horns of these switches are going to rise to extinguishment and, in rising, should not be communicable to the steel structure, or to other equipment.

Choke Coils, Fuses, Etc.

Reinforced choke coils, of the type rigidly mounted on insulating supports, as well as the unmounted and suspension types, are available in so many forms and combinations with other equipment as to

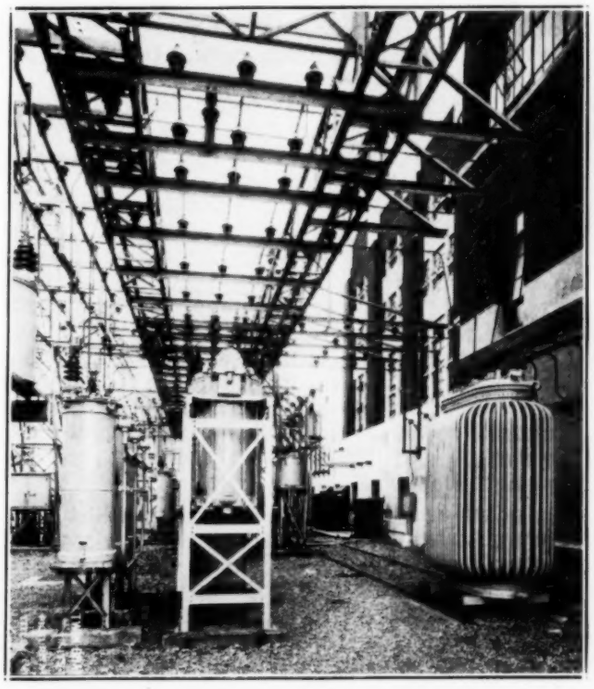

FIG. 3—One section of a 33,000 volt substation.

remove entirely any further excuse for error in their application.

Fuses, formerly the nightmare of the operating man, have been developed to a high state of perfection and the problem now rests with the sub-station designer to so place them that it is possible for the operating man to remove and replace them without calling into play pro-Darwin forms of gymnastics.

Insulators

As is well known, electrical disturbances of a transient, but none the less destructive, nature are apt to pile up at sub-stations and similar points on the system. Careful study therefore should determine the insulating or flashover value to be employed on a given station.

It is wholly insufficient to compute or guess what this value is going to be in a piece of finished equipment, even though the flashover of the insulator employed may be definitely known. The finished equipment should be carefully tested and its various characteristics definitely established.

General

In a relatively short span of years the outdoor sub-station has advanced from "a little thing out at the edge of town" to a post of very definite responsibility in a big important element of the scheme of things today. It has ceased to be a trivial matter, passed on to a line foreman after brief discussion. It is one of the many nerve centers of the modern power distributing system of this great nation, and the failure of just one small piece of equipment on the modern outdoor sub-station will frequently work as much havoc in the continuity of service as the failure of a 75000 KVA turbine unit. Is it any more than fair then, that the outdoor sub-station should receive the same character of consideration, its design be based on the same careful tests and reasearch has characterized the design and construction of the more spectacular elements of the modern power system? Your own fair sense and judgment will answer the question for you. You are the jury.

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*Spacing of Heavy Capacity Low Voltage Cables**

By W. H. BOYCE†

THE problem of proper spacing between centers of low voltage cables, carrying heavy currents, is often times more complicated than would appear at first.

It is the purpose of this paper to consider the relation of the two principal methods employed in arranging exposed cables in Mill construction. This applies only to conductors run in air, mounted on suitable supports and not enclosed in conduits or ducts.

The ideal method of running the 3-phase, 3-wire circuits, is to arrange the wires or cables so that the centers coincide with the points of an equalateral triangle. This arrangement has the advantage that each wire or cable is influenced by the currents and the consequent magnetic fields of the other two wires in equal proportion. This arrangement is the one referred to in practically all of the hand-books in connection with calculation involving reactance and voltage drop.

The other arrangement, and the one which is in most common use, is to run the three wires with equal spacing in the same plane. This has been done in a great many cases, due to the ease of construction, as most any type of cable support is adaptable for this construction. However, there are cable supports on the market for supporting the wires in triangular formation. It is our endeavor to make a comparison of these two methods.

Before proceeding with the direct comparison on 3-phase circuits, it might be well to review the fundamental considerations for direct current circuits.

The principle facts to be considered are the voltage drop and permissable temperature rise at full load. Both of these are dependent upon the length of circuit and resistance of the wire or cable used.

The so-called proximity effect of conductors carrying heavy currents may, at times, tend to increase the voltage drop on long circuits, however in the majority of cases this effect is so slight in direct current circuits that, for all practical purposes, it can be neglected.

One of the simplest methods for calculating the proper size cable to transmit a given load a certain distance, with a definite voltage drop, is based on the following formula:

$$\text{Circular Mills} = \frac{\text{Feet (supply to distribution)} \times 2 \times 10.7 \times \text{Amperes}}{\text{volts lost.}}$$

The result of the above formula should always be checked with the Underwriters' table of carrying capacities of wires and cables, and in the event of the result being smaller than the specified size for the same current, the size specified by the table should be used. The following example will illustrate this:

Assuming our load to be 400 amperes, to be carried 500 feet, with a 5% loss at 260 volts, or a total of 13 volts loss. Applying our formula, we then have:

$$\text{Circular Mills} = \frac{500 \times 2 \times 10.7 \times 400}{13}$$

or 329,230 C.M. as the result.

Taking the nearest commercial size, which would be 350,000 Circular Mills, we find that the Underwriters' Table shows this particular size is allowed 300 amperes for rubber insulation, 360 amperes for varnished cambric and 450 amperes for other insulation, such as slow burning or weather-proof. Consequently, if you wish to use rubber insulated cable and keep within the Underwriters' specifications, you will have to use a 500,000 Circular Mill cable, which has a rated capacity of 400 amperes.

Now, if you wish to check back and ascertain what the voltage drop will be, using this size cable, we transpose our formula, thus:

$$\text{Volts Lost} = \frac{500 \times 2 \times 10.7 \times 400}{500{,}000}$$

or 8.5 volts lost

Single phase, A.C. Circuits are, in general, of moderate capacity and for practical purposes, can be figured the same as a two-wire, Direct Current Circuit with but a small percentage error.

Where the currents are large, the "skin effect" as well as the reactance, will have to be taken into consideration. Figures will be discussed later.

Two Phase, four wire circuits can, in most cases, be considered as two single phase, two wire circuits and handled as such.

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*Presented before Chicago Section, November 15, 1927.

†Designing Engineer, Delta-Star Electric Co., Chicago, Ill.

Three wire, three phase circuits present the greatest number of problems for our attention. Our voltage drop, in this case, is dependent, not only upon the distance and resistance of our cable, but the reactance and "skin effect," as well as the capacity and proximity effect. If we consider these factors one at a time, it may be well to start with the so-called "skin effect" and its relation to the increased resistance of our circuit.

"Skin effect" is the term applied to that property of an alternating current which tends to cause it to flow on or near the surface of a conductor, instead of being equally distributed through its entire cross-sectional area. The percentage increase of resistance due to "skin effect" will vary with the size of the cable and with the frequency of the circuit. In other words, it is much more pronounced at 60 cycles than at 25 cycles.

There are several different formulas for figuring the "skin effect" on cables; no two of which exactly agree. However, Messrs. Middleton & Davis conducted a series of tests covering the actual increase in resistance, due to "skin effect," on various sizes of cables and at different frequencies. The results of these tests were published in the September, 1921 issue, Journal of the American Institute of Electrical Engineers. Consequently, the writer believes it will be reasonably safe if we figure the increase in resistance in accordance with their findings.

For the purpose of comparison, we will consider the 60 cycle "skin effect" on the commercial sizes most frequently used.

Below are given the various factors for multiplying the D.C. resistance of four different conductors in order to get the total resistance, including the "skin effect" of the current:

	25° C.	65° C.
500,000 C.M.	1.005	1.004
1,000,000 C.M.	1.132	1.115
1,500,000 C.M.	1.275	1.239
2,000,000 C.M.	1.400	1.348

Without going into the various steps of the extensive calculus involved, we will endeavor to show a comparison in the actual voltage drop for these four sizes of conductors, with different spacing for both triangular formation and with three wires in the same plane.

The reactance factor for cables is variable and is dependent upon the power factor, so, for the purpose of our comparison, we will confine ourselves to a power factor of 80%, which we believe, can be taken as an average inductive motor load. For ordinary commercial practice, we can neglect the so-called proximity effect, as well as the capacity factor, as they will introduce only a very slight error in the total result. Returning to our comparison of the four sizes of cable above mentioned, this has been worked up in the form of a series of curves shown in the following chart. This includes the "skin effect" of current and the resistance corrected to 65° C.

We have taken first, the item of 6" spacing between centers of conductors, because of the fact that the Underwriters' Specifications call for 4" separation between conductors of voltages from 300 to 600, and in a great many cases, it is common practice to run them in this manner.

The top curve in this chart shows the total impedance factor in percentage volts drop per ampere per 1000 feet for the four different sizes of conductors, when run with three wires in the same plane.

The second curve shows that the impedance is somewhat less when the wires are run in a triangular formation, with the centers an equal distance from each other.

The third curve shows the wires run in a horizontal plane at 4" centers. This distance was selected for this comparison because of the fact that the Underwriters' Specifications call for 2½" spacing between the outside of conductors of 300 volts or less.

The fourth curve shows the impedance factor for triangular formation on 4" centers, which is still less.

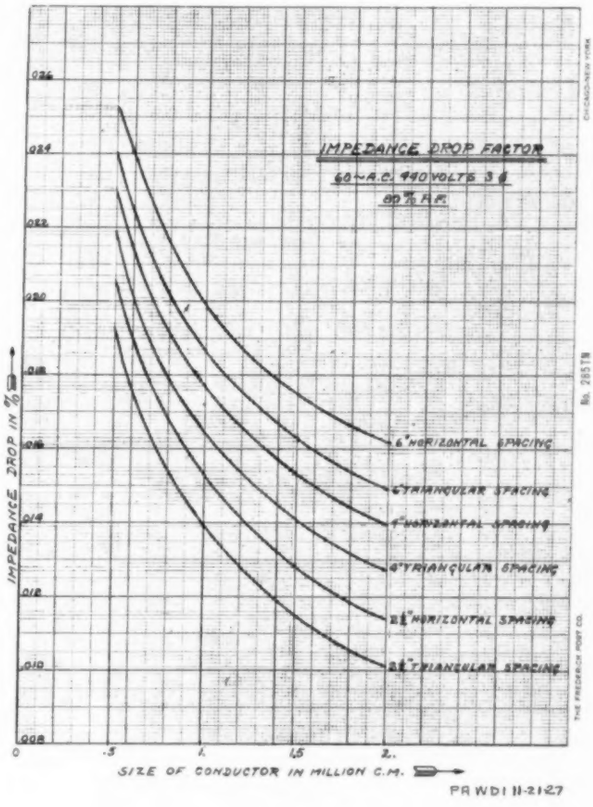

FIG. 1.

Curve number 5 shows the result if the cables are run on 2½" centers, with horizontal formation. In ordinary practice, this is very seldom done, on account of the difficulty in getting the cable supports close enough together to arrive at these centers. However, it can be seen from the chart, that if this can be done, there will be a further decrease in the impedance factor.

The sixth curve shows the result if the wires are run on 2½" centers in triangular formation. This can be, and is very often done with the smaller cables. On larger sizes it is sometimes necessary to increase this spacing slightly, due to the construction of the supports.

As a matter of comparison between various spacings shown in the curve, we find that the voltage drop for 500,000 Circular Mills cable will be slightly

more than 23% greater when run on 6" centers in a horizontal plane than when run on 2½" centers in triangular formation. For one million circular mills cable, it amounts to practically 30% greater. For one million and a half circular mills cable it is 36½% greater and for two million circular mills cable, 41½% greater.

The above figures are, we believe, somewhat conservative, and as before stated, are taken on the basis of 80% load power factor. At higher power factors, the difference will not be as great, due to the fact that the inductive reactance of the circuit, combined with that of the load, becomes of relatively less importance. Inversely, as the power factor decreases, the difference between the two will increase.

It is not our purpose to advocate a flagrant violation of the Underwriters' Code, but it is obvious that considerable advantage is to be gained in the decreased impedance factor and consequent lower voltage drop by the smaller spacing. In certain cases, where the judgment of the engineer would indicate that this would be safe practice and the inspectors will permit its use, it may be advisable to use this form of construction.

Switching Instructions, Electrical Dept., Lackawanna Plant, Bethlehem Steel Company

Instructions for Station Attendants

1. Oil Switches on incoming transmission are never to be opened except on orders from Power Department. Always find out name of person giving the order and find out why and write it in the log book. Power may be passing through your oil switches altho your station is entirely down.
2. The Power Department will provide you with a sign wide enough to cover the three phases of a circuit with the following sign:
   Do Not Open—Unless Ordered by Power Dept.
   which you will be held responsible to see that this sign is always kept in the proper place over the three disconnecting switches belonging to its respective circuit. Any work being done on the line this sign shall be covered by a sign of same width with notation.

Danger 6600 Volt—Leave This Switch Out

3. Always be sure that you are pulling the disconnect switches for the same oil switch you have opened. Opening a disconnecting switch on either side of the three which you have cleared by opening the oil switch may mean the interruption of large amount of power and may also mean the loss of your eyesight. You have only ONE PAIR OF EYES and you better PROTECT THEM.
4. No disconnecting switch is to be pulled before checking that oil switch connected either in front or back of this switch is open. This means that not only is the oil switch control switch to indidicate "green" but that lever on top of oil switch is to be checked for open position.
5. All switching inside a station will be done only by that operator. The repairman when satisfied that switch and disconnects are opened must fasten tag and lock on switch handle and switch handle must not be closed until tag and lock is removed by repairman. The form tag used gives the repairman's name, check number, date, where work is being done and approximate time work will be finished.
6. Extreme care should be taken that all three disconnecting switches of a circuit are opened if one is opened and that all three disconnecting switches are again closed before oil switch is thrown in, in case you have occasion to open any circuit. When you are sure you are ready to close a disconnect switch close it home. Do not feel for a circuit with your knife blade. If the circuit is in trouble better have the oil switch trip out than to have the arc in the air in front of you.
7. In case any work is to be done on either 440 volts, 2200 volts or 6600 volts, rubber gloves with leather gloves over them are to be worn at all times.
8. Care should be taken that any portion of the body may not come within one foot of any live 6600 volt circuit. In working around disconnecting switches do not depend on any old wooden box covering up these switches. Some nail you didn't see may bring 6600 volts through you. Use a properly formed high voltage rubber matting in addition to any other barrier you have and wear your gloves. Keep your knees out of the cells.
9. If it is necessary to work on your MG sets or transformers disconnecting switches are provided for clearing this equipment from the bus.
10. Always remember a transformer backs up as well as steps down. Altho you may have opened your oil switch on the high side you may still have 6600 or 440 volt on your transformer from the back feed. Always clear both sides of a transformer before working on it. Motor generator sets may also back up through the D. C. end in case of failure of A. C. running switch to trip out.
11. When working on a current transformer for meters or relays always short circuit the secondary before opening the meter or relay contacts. Never open the secondary of a current transformer as it has a very high voltage kick and you may be burned severely.
12. Check your ammeters, wattmeters and watthour meters daily to see that they are functioning properly and become familiar with what loads you may expect. Anything abnormal is an indication something is in trouble and should be immediately reported to Electrical Supt. Office.

13. Any relays not functioned properly should be reported and stated on log and every interruption of power should be logged carefully, giving time "off" and "on" with any information concerning the trouble that you may know about.
14. After switches are pulled and repairman has made sure the lines are dead, he must short circuit all three phases with grounding lead and insulating stick provided for this purpose. This ground lead must be removed by repairman when work is completed.
15. After work is finished repairman must notify operator that line is clear and circuit can be closed, remove his tag and lock, tag to be kept by operator for file record, and record made in log covering the cause and all information available concerning work done.
16. Remember that your life as well as the life of your fellow worker is always in danger when switching high tension voltages. If in doubt get clearance from some one who knows.

Modern Structural Industry Demands a Knowledge of Arc-Welding

By C. J. HOLSLAG*

THE arc-welded joint possesses 100% strength and efficiency; the riveted joint has but 50 or 60%, and this fact alone is a valid reason why the welding process should be widely adopted. The arc-welded joint has now been so successfully tested and applied in actual building and even bridge-construction, and so many firms have found its use a practical economy, that it would seem that now is the time for publicity to make its application universal.

The amount of metal that has to be deposited in order to make a 100% joint is not excessive. As a matter of fact, even in the present stage of development its cost is less than other processes. The amount of deposited metal that would be required to provide the strength of the original material, whether sheer, tensile, bending, compression, or alternating stress, may be very easily figured from the fact that accepted tests of the tensile strength of the welding metal show 50,000 to 60,000 pounds, and a shear stress of 30,000 to 40,000 pounds per square inch, assuming a factor of safety of four would still not imply any excessive amount of welding. These figures may be readily substantiated by reference to the Wirt-Jones test, made at the American Bureau of Standards and published by the American Welding Society and the American Institute; or to the test made by the General Electric Company, in collaboration with Union College; or to the results of the Westinghouse actual structure, and to the test made in Mellbourne, Australia, by the Metropolitan Gas Company's Engineering Department. This latter test, by the way, was the most elaborate yet attempted and the results, which are excellent, appear in print in "Canadian Machinery" of March 4, 1926.

As far as assembling details are concerned, welding provides the utmost flexibility and convenience. Attaching plates and turn buckles, when they have served their purpose, are simply knocked off with a blow at right angles to the line of weld. In short, these temporary jigs and fixtures are purposely weak only in the unimportant direction, and strong only in essential and important direction.

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For the last two years it has been conceded that the poor tank is the one that has not been welded. When this fact is coupled with the further fact that welded heating boilers are here and locomotive boilers and frames have been pounding over roads for nearly twenty years, it would appear that the only obstacle in the path of arc-welding is the old human one of psychological inertia. Large oil tank roofs and bottoms and many complete structures are already to the credit of this process. The American Bridge Company is re-building a large span at Leavenworth, Kansas, and using arc-welding to do it.

Bridge-welding, of course, is not the simplest and most obvious kind of welding. The best place to learn welding is in the shops—on window frames, door-frames and odd pieces, repairs, etc. In actual building construction, the roof might perhaps seem the logical place to start, because on the roof-work the welding process shows prompt results, both in speed of work and in cost-saving to the builder. This holds true for both gas and electric-welding.

The advantages of structural arc-welding have received publicity by reason of the fact that various welding apparatus companies have built and tested experimental buildings, roof-trusses, etc. What of buildings, however, that are designed not for experiment, but for actual everyday service? This article deals primarily with arc-welding structural work that is in actual service after acceptance by civic and state authorities.

In this connection I may mention the roof-truss that was shown arc-welded by the Electric Welding Company of America, and which was approved by the New York City authorities several years ago. Again, I may mention buildings erected by the General Electric Company, the Lincoln Company and the Westinghouse, as well as our good own selves. This process was used in each case. The buildings were all made with standard structural shapes, not all of which fit readily into the scheme of electric arc-welding. The accompanying photographs, some of them taken from a catalogue (which adds force to the statement that arc-welding is an accepted thing) will show structures wherein the metal is adopted to the designer's idea of the best shape for the arc.

It may come as a shock to those who adhere to earlier ideas of steel practice, to learn that webs of angles, channels, and I beams are not always necessary and that the strength can best be met by other means. As an instance of this, may be cited the structure put out by the various people making these new bar joints. This truss is practically made of rods, welded together. The bottom and top chords, as well as the struts, are igeniously formed out of bent rods, arc-welded together. Where they meet at each end they are joined by the same process to a standard structural shape. This truss, by the way, is a real truss of the Pratt type, and when used with concrete or steel as a floor or ceiling it produces a most economical construction.

As final proof of the value of the arc-welding process I might point to about 30 buildings here in the metropolitan section among which is a completely welded house at No. 766 Carrol Place, Teaneck, N. J., made by Jos. J. Dudley of the Welderete Company and the Electric Arc Cutting and Welding Company. The house is very similar to that of the wood-frame type, except that steel alone is used. It was built from flat and standard sections which were lifted into place and the sections welded together. All cutting on this job was also done with the arc.

Another building embodying only welded construction is being erected at 152-156 Jelliff Avenue, at the plant of the Electric Arc Cutting and Welding Company. The roof is made with the standard trusses of the Concrete Steel Company, the columns are welded Lally columns, which for years have been accepted as standard by all authorities and are made entirely by welding. The special frame at cap and base is nicely adapted by this process. In short, wherever a joint occurs, it is made by the welding process.

Still another beautiful adaptation of arc-welding lies in the attaching of roof parlins to the rafters, where a fire-proof slab roof is used. Such a one is substituted by the U. S. Gypsum Co. or the Porte Mfg. Co. The standard T bars, formerly drilled, bolted or tapped in place, by hand, on the roof, are replaced by simply cutting and fitting the pieces and tacking them in place by arc-welding. A single welder is able to attach in this way as much steel as a whole gang of iron-workers. When it is realized that on gable roofs practically every piece has to be fitted in place on the job, the advantage of welding is obvious.

A list of buildings in this vicinity, that have been welded in this way, follows:

Eighty-sixth St. and First Ave.—Theater—N. Y. C.
Fordham Road and Jerome Ave.—Theater—N. Y. C.
Mt. Morris Ave and 186th St.—Theater—N. Y. C.
Mt. Eden Ave. and 176th St.—Theater—N. Y. C.
Eighty-sixth St. and Lexington Ave.—Theater—N. Y. C.
Parkway Baths, Brighton Beach.
Loew's Theater, Main Street, White Plains, N. Y.
Loew's Theater—Main Street. New Rochelle, N. Y.
Masonic Temple—W. Broad St., Elizabeth, N. J.
Marcus L. Ward—Home—70,000 ft. roofing—Maplewood, N. J.
Bound Brook Theater, Bound Brook, N. J.
New Maplewood Theater, Maplewood, N. J.
Holstead Theater So. Orange Ave., Newark, N. J.
Moving Picture Theater, Stuyvesant and Morris Aves., Union, N. J.
Col. Roger's Hunting Lodge, So. Hampton, Long Island.

The apparatus with which this work is done is incidental, and any machine may be used. In the building at Teaneck, mentioned above, A.C. was used, two and four machines being operated from one line transformer. In the foreto installation, generators made by the writer's company were used. In the U. S. Gypsum installation generators of various makes were used. Some were motor driven, others were gas-driven. In general, where there is electric power available, it pays to have a separate meter put in for the welding.

New York is not the only city to use this process. Other cities have fallen into line, especially Cleveland and Detroit. In other words, the idea of structural arc-welding is a national idea, not a local one. It is not necessary, of course, to go to the extent of putting up a building in order to use structural welding to advantage. There are thousands of other needs. It may be used in the shop and in the field. In design, in piecing out and joining members together to fit special needs; iron work, ornamental, special, etc. In such cases, welding will pay for itself many times over. The first structural welding ever done that I know of was at the Erie plant of the General Electric Co. in April, 1918. This was a complete elecltrical loco. cab, frame, windows and doors and apparatus brackets, and is still being operated.

Building alteration is being done and has been done in various cities by the electric arc process. The Foundation Company has just completed a very imposing task of this kind on the interior steel structure, boiler-framing, etc., of the Prudential Building at Bank and Broad Streets. Arc-cutting and welding was used extensively on this job; the cutting to remove parts, and the welding to fit them and replace them. Alternarc machines were used combining our facilities for cutting and separating them into 3 or 4 for welding. On the subject of this cutting, it may be noted that the previously mentioned Welderete-Teaneck job was handled by the metallic cutting electrode and the two arc-welding one arc-cutting A.C. machine.

The capabilities of electric arc-welding are more perfectly adapted to structural work in metal than perhaps to any other single industry. There is no imaginable form of steel structure, large or small, that could not advantageously be put together by welding. Not only does welding offer the structural industry greater facility, efficiency and durability in the results it produces, but it accomplishes these results at an appreciably lower cost, and this applies not only to all steel construction but to any construction in which metal is joined, and where the joint is required to be strong, tight and lasting.

The peculiar qualities of the electric arc which render the process so well suited to all forms of structural work, appear most strikingly in building construction. The most important quality to structural designers and contractors is that of rigidity, for if the joint possess rigidty and strength, the problem of designing and proportioning the entire structure may be solved with confidence. The aim of welding engineers should be to produce this confidence in the process-result. That they have been successful in their aim is amply proved by our records of proficiency.

Another important factor to be considered is the workability of the arc-process. To begin with, a single machine and its operator forms a complete

producing unit, which can work independently. Contrast this with the riveting in construction work. The latter demands a gang of men for punching, fitting, aligning, heating and riveting. If a single one of these steps is poorly or inaccurately done, the entire result suffers. In welding, on the other hand, the operator, the electrode and the machine, alone determine the result. When the machine is in good shape and proportioned to the work at hand, the rest depends upon the operator. A good machine helps a good operator. It is better, therefore, to depend upon one good machine and one good welder than to multiply the chances for inaccuracy and incompetence.

The following is a brief analysis of the contrast:

Economy—Electric welding heat—3c to 5c per hr. at 3c per K.W.H.
Gas Welding heat—$1.00 to $2.00 per hr.—supplied by generator or tank.
Riveting—Total cost of gang for same work, 50c to $1.00 per hr.
Results—Actual tests determine the strength of a single riveted joint to be about ½ that of a welded joint.

A subject more fully appreciated, perhaps, is the matter of tightness of welding. Since many tanks are practically structural in design, the subject deserves a place here. Riveted joints that are required to be water, air or gas-tight must be carefully filled and caulked; there is no other way out of it. On the other hand, a welded joint is by its very nature tight without caulking. There is no warping or twisting in such a joint. For this very reason welding is often used to close up already riveted seams when other methods to make a tight joint have failed, owing to the continual lessening of the rivets. By all logic, why not construct the joint by arc-welding in the first place?

Another tremendous advantage of the electric arc in construction work is its great **adaptability in creating on the spot structural shapes to meet any particular need.** For this reason builders find the arc process capable of the most extended service in such a variety of applications as metal window framing, corner-angle work, metal stairways, newal posts and hand-rails, doors and door-framing, stiffening members, chutes, hoppers, balconies, straps for holding piping and conduits, etc. These are but a small fraction of the number of uses to which this process can be put.

Workers in iron and steel of all types of products have found the arc-process universally adapted to their needs. Ornamental iron-work of every nature is done more efficiently and more neatly by means of electric-welded joints. The arc in this work makes possible the smooth realization of the design with no unsightly rivets or bolts. And apart from pleasing the eye, the joint is the strongest and most durable one that can be made.

But, as electric welding is relatively new in the structural field, the designer will have to cast aside many of his prejudices (used, originally, by the limitations of other methods) and learn to know welding. He will find, first, that his work is simplified; second, his results are less a matter of uncertainty. Let him study with an open mind some good welding Handbook. Such data should be in the hands of every engineer, construction designer or user who wishes to examine honestly the advantages of arc-welding.

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*Motor Rollers**

By A. M. MacCUTCHEON†

PREVIOUS to today, the general subject of motor rollers has been presented before various groups of the Association of Iron & Steel Electrical Engineers. At the annual convention in Pittsburgh, several motor rollers were exhibited in operation.

Today, it seems difficult to cover the subject with so many other interesting things on the program. Perhaps it would be well to assume that no one here has heard anything of the motor roller, as a description presented from this viewpoint will be more complete than though it were assumed there was some knowledge on the subject.

This motor roller of which I speak, is a device that was developed on the other side of the ocean and was there patented. The patent rights are held by the Schloemann Engineering Co., of which Company, Mr. Feller, who is today present, is the representative. It is not difficult to get a conception of what this device is from the electrical end. If the ordinary induction motor were built with an extended shaft and the motor supported from the shaft with the stator free to rotate, the stator would rotate when power were applied to the terminal of the windings. If it were desired to use an ordinary induction motor in this way, it would be wise to put the stator winding with its core on the shaft and the squirrel cage rotor winding with its core on the outside member. Power could then be conducted into the stator winding without slip rings.

The motor roller is constructed in this manner. In order to carry steel, it is desired that the outside part should rotate, therefore the squirrel cage winding with its core is introduced into the shell of the roller. The stator core and its winding are mounted on the stationary shaft. The shell, or outside rotating part, is supported from the stationary shaft by means of ball or other type of anti-friction bearings supported in suitable housing.

It should be noted that the use of roller or ball bearings in this device differs from the usual application of such bearings, in that the inner race is mounted on the stationary member and the outer race is mounted in the rotating member. All anti-friction bearing authorities agree that the race which is mounted on the non-rotating part should be a tight fit and the race which is mounted on the non-rotating part should be a sliding fit. In this device, therefore, the inner race should be a tight fit on the stationary shaft and the outer race a sliding fit in

*Presented before Pittsburgh Section, December 17, 1927.
†Vice Pres., Engr., Reliance Elec. & Engr. Co., Cleveland, Ohio.

the rotating part, which is just the reverse of the condition desired on an ordinary induction motor.

The speed of the roller depends upon the number of poles in the stator winding and the frequency of the supply source and may be operated from any AC source of supply provided that with the number of poles possible and the frequency of the AC supply, the desired speed may be secured. It usually works out that it is not possible to operate from a higher frequency source of supply than 25 cycles, as it does not appear to be practicable to wind the motor rollers with more than 16 poles and the use of 16 poles on a higher frequency than 25 cycles generally does not result in a low enough speed of the motor roller.

If a motor roller or a group of motor rollers is operated from a generator driven by a DC motor, it is possible to control very satisfactorily the speed of the motor rollers by changing the speed of the DC motor driving the AC generator. I believe that this is obvious to all. With no change in the alternator field, increasing the speed of the AC alternator results in an increased voltage in proportion to the speed increase. When operating a group of motor rollers with a speed change secured by the apparatus described, no change should normally be made in the field of the alternattor. In other words, the AC alternator supplying power to the motor rollers, should be operated at a fixed flux.

If the field of the alternator is strengthened, resulting in a higher voltage at the same frequency, increased torque may be secured on the motor roller.

I do not believe it is desirable or necessary to go into the very large number of uses of this motor roller throughout steel mills. These uses will be obvious to you all.

Referring back to the question of changing the speed, it will be interesting to you to know that experiments have been made where a group of motor rollers has been operated on a frequency of from 3 to 60 cycles, giving a speed range of 20:1. As far as the motor roller itself was concerned, operation was entirely satisfactory. It is recognized, however, that such a speed range on a DC motor driving the AC generator is not possible excepting by means of voltage control on the DC motor or combined voltage and field control.

When operating at a certain frequency and voltage, if a higher torque is required, this higher torque may be secured by increasing the voltage of the AC supply, as in any induction motor, the torque will increase as the square of the impressed voltage. By so increasing the torque, a very rapid reversal may be secured. I do not feel that there is any practical limitation as to the rapidity of reversal which may be secured. To build into a certain roller an induction motor which will develop the necessary torque for a more rapid reversal will require more electrical material at more expense than is necessary for a less rapid reversal, but the desired rapid reversal can undoubtedly be secured.

Since but very little power is necessary to operate the motor roller when it is not called upon to accelerate a piece, the continuous power demand is small. It is felt that in general it is wise to so design the induction motor as to secure a maximum torque at standstill. This will certainly be the most satisfactory design if the motor roller is used to accelerate material. When the motor rollers are running continuously, a very slight change in load is observed, whether or not material is passing over the rollers. A number of tests have indicated that the increase in power input when handling material over a continuously running table is less than 6%. On no test has there been an indication of more than 10%. It should be remembered, however, that this condition exists only when the material is free to travel at the surface speed of the roller. If, on the other hand, material is issuing from a mill with the speed of the movement of the steel controlled by the speed of the mill and is being delivered to a motor roller table where the surface speed of the motor rollers is considerably higher than the speed at which the material is issuing from the mill, a very considerable load will be imposed upon the motor within the motor roller. Either the motor roller must slow down due to the electrical load which is being imposed upon it, or else the motor roller must slip under the steel, which also means a considerable increase in electrical load. If the speed of the mill is higher than the speed of the motor rollers, it is possible to transform the motor roller into an induction generator.

The motor within the motor roller should be designed with low losses since it operates as a fully-enclosed, continuously running motor. However, if the use of the motor roller is intermittent, operating for a certain period and then remaining idle for a certain period, the same amount of electrical material can, by the proper design, produce a very much larger torque than when the roller is running continuously. Usually when there is this intermittent operation, the work to be done is in connection with accelerating a piece of steel and under this intermittent operation, the motor roller may be designed from the standpoint of producing the maximum torque which is most desirable when the work which the motor roller is to do is considered.

In my connection with the application of motor rollers, I have been impressed by the fact that each particular application must be considered separately. Each application differs somewhat from any other application. This statement naturally does not apply when the particular case being considered exactly duplicates in all ways, another case, then the motor rollers will be duplicates, but as a rule, we find that it is necessary to give specific consideration to any specific job rather than attempt to generalize as we do in building regular motors.

Motor rollers fall under the general classification of individual roller drive and in considering their use, it must first be determined that the application being considered justifies an individual drive for each roller. As a rule, any form of individual drive on a roller is more expensive than a group drive with gearing and a single motor, but there may be such advantages as would justify the increased investment. When we think back to the application of motors in a machine shop, we recognize a similarity. In a machine shop, individual drive in its first cost is more expensive than group drive, but practically all up-to-date machine shops go in with individual motor drive because the advantages offset the increased investment.

If it has been decided that the increased investment in individual drive is justified by the advantages, consideration should be given to the various

methods of getting this individual drive and it is my belief that the motor roller has a great many advantages over any other type of individual roller drive. Less room is required, all gearing is eliminated, the motor rollers may be readily removed and what I think is most important of all, no misalignment can occur. In the case of the motor roller, all parts take their alignment from the stationary shaft. If one side of the stationary shaft is lowered, no misalignment results within the motor roller. The motor roller may be placed on end and successfully operated.

I hope to have the opportunity of presenting more completely the whole subject of motor rollers before the Association and will be very glad at this time to answer any questions that may come up.

DISCUSSION

D. W. Dean*: In discussing the various applications of individual roll drive, it will be advisable to consider the different types of roll table applications encountered. Various table applications might be classified as follows:

A—Heavy duty reversing tables.
B—Reversing tables of comparatively light duty.
C—Continuous duty non-reversing tables.
D—Tables normally continuous running but requiring occasional quick stopping and starting.

The individual roll motor drive is not practical on heavy duty reversing tables such as the main tables on reversing blooming mills. Here very frequent reversals are required and the reversals must be accomplished in only a few seconds. The considerable inertia encountered makes it entirely impractical to apply the individual motor drive due to its limited torque, the starting torque of the induction motors used on individual roll drives seldom exceeding 150 per cent of full load torque. If the attempt is made to apply a motor of sufficient torque rating to overcome the table inertia and accomplish the required reversing cycle, then the motor inertia far exceeds the roll inertia and the motor size or rating has become so big that the application of the individual roll drive to heavy duty reversing table service becomes economically impractical.

Mill approach, and shear approach and delivery tables might be mentioned as reversing tables of comparatively light duty. On these applications reversing and plugging does not normally occur as frequent as on reversing mill main tables but quick acceleration and deceleration is required. On these tables it will also be found that the maximum starting torque of individual roll motors which might be economically applied is insufficient to meet the usual duty cycle, so that the individual roll drive is not applicable to this class of roll tables.

On continuous duty non-reversing tables, such as the runout tables of hot strip and bar mills, is found the main field of application of individual roll motors.

On some tables used normally as continuous duty non-reversing it is occasionally necessary to have quick stopping and starting.

On all tables where quick stopping and starting, or frequent reversals, may be required, the application of the individual roll motor with its motor-generator set must be carefully studied. The usual application involves a number of induction motors, possibly from 20 to 80 or 90 in number, all receiving power from a motor-generator set, usually driven by an adjustable speed d.c. motor. The individual motors may be stopped by plugging the induction motors, by plugging the direct current motor of the

FIG 1—78 0.5/0.25 HP 960/480 RPM Individual Roll Motors Laclede Steel Company.

motor-generator set, or by dynamic braking of the d.c. motor on the set.

It is seldom practical to obtain quick reversal of the table by plugging the induction motors. The plugging current would be several times full load current, and of low power factor, 18 or 20 per cent. This low power factor plugging current has a demagnetizing effect on the generator of the m.g. set, with the result that on plugging the motors the generator voltage collapses, with resultant loss of plugging torque. This makes it impossible to

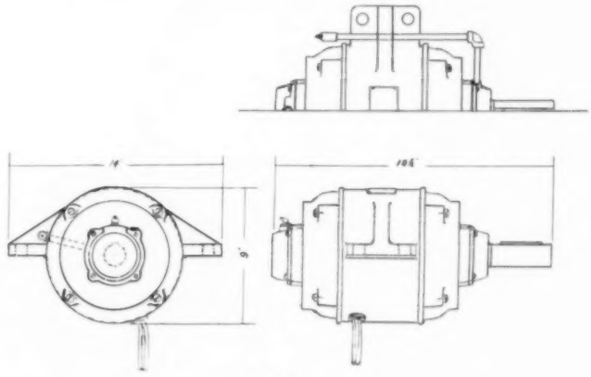

FIG. 2.

ever approach a quick stop of the table by plugging the individual roll motors unless a special synchronous generator is used. Even with a special oversize generator to prevent collapse of voltage on plugging, it will be only in special cases of low inertia tables where quick stopping or reversal of the table can be secured by plugging of the individual roll motors because the full voltage plugging torque will exceed little if any the full voltage

*Engr., West. Elec. & Mfg. Co., East Pittsburgh, Pa.

starting torque, and as this torque is usually less than 1.5 times full load torque it is evidently impractical to obtain quick acceleration or deceleration by plugging the individual roll motors.

These comments should not be construed as general arguments opposed to individual roll drives on mill tables. Recognizing the limitations of this type of roll table drive does not lessen its advantage on runout tables where frequent starting and stopping is not required.

There are various methods of applying individual roll motors. In some cases induction motors of practically standard construction are flexibly coupled to the rolls, this method being used on the wide strip mill at Weirton.

Fig. 1 shows an installation where the roll is mounted on the motor shaft, entirely supported by the motor bearings. This installation involves 78 motors rated 0.5/0.25 H.P., 34/17 cycles, 960/480

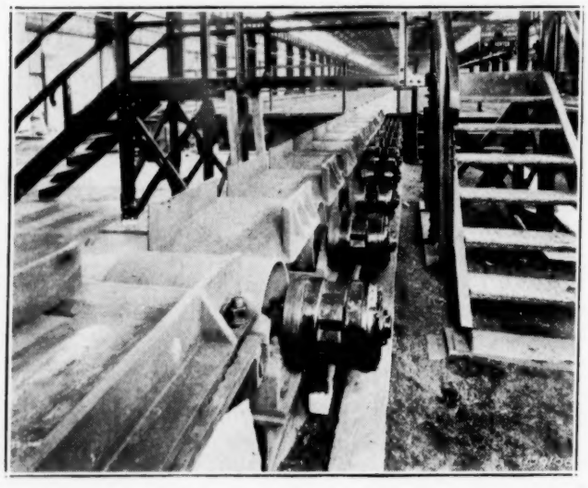

FIG. 3—95 0.5/0.25 HP 350/175 RPM Individual Roll Motors Laclede Steel Company.

R.P.M. The outline sketch Fig. 2 shows the motor feet cast integral with the frame and so designed that the motor is supsupported at the center.

In some cases the motor rotor is pressed on an extension of the roll shaft. The back bearing bracket of the motor is not used. Fig. 3 shows a strip mill runout table where 95½ H.P., 350 R.P.M. motors are used with this mounting arrangement. Then there is the method of applying individual roll motors with the motor built into the roll as described by Mr. MacCutcheon.

Most operators prefer a method of applying individual roll motors using motors of standard or near standard construction as they feel they will obtain greater economy in inspection and maintenance than will result from the use of special construction.

Mr. MacCutcheon has mentioned an application using individual roll motors where reversal takes place in 2¼ seconds. It would be interesting to know whether the motors are plugged, or whether the M.G. set is reversed.

Frank W. Cramer*: In a discussion of motor driven rollers, the various control schemes used on these installations should be given consideration. At our Johnstown Plant, we have the hot bed run out tables on three mills equipped with the individual motor driven rollers. At each of these mills, there is a motor-generator set to supply the power for the roller motors. The mill operator controls this set by means of push buttons for starting and stopping, and also a motor driven rheostat that regulates the motor speed. A meter calibrated in R.P.M., mounted on the pedestal with the push buttons, indicates the speed the rolls are running. On each mill, there are five circuits installed to the rollers every fifth motor being on the same circuit. With this design, should we lose a circuit, the operation of the mill would not be interfered with, as there would still be four live rollers between the dead ones. Each motor is also equipped with thermal fuses that open in case of overload. This scheme of giving the operator only push button control has proven very satisfactory after two years of service. The main control boards and M.G. set are in a separate room that is kept locked and accessible only to the electrical inspectors. The feature of allowing the motor-generator set to bring the roller motors up to speed gives a smooth, easy start for these small motors.

Some of the engineers have been insisting that when individual motor driven rollers are purchased that their voltage range should be such that they could be thrown over on the mill supply should the motor-generator set fail. When this scheme is considered, the speed of the rollers at the mill frequency should be looked into, as this might not fit the rolling speed of the mill, hence the roller table would be of little use when operating on the mill supply. Another method is to purchase some spare equipment for the set. Probably the longest delay you could get would be if the AC stator should burn up and have to be rewound. The cost of a spare stator, and a DC armature is only a small percentage of the total cost of the installation. With three mills equipped with this type of roller, we installed a spare M.G. set that by means of double throw switches can be used on any mill. Although this spare set is used frequently, in order to have the inspectors familiar with the operation in case a breakdown does occur, in over two years of operation of three mills, we have had no trouble with the three regular sets or their control equipment. Such a record indicates that the equipment is reliable, and that the question of being able to operate on the mill system is not of prime importance.

Another interesting feature of these installations was mentioned by Mr. MacCutcheon. The actual load on the motors does not vary much from running light to running with steel on them. The real load comes when the piece is still in the pass, and the rollers are spinning under the bar. It is mill practice to run the tables about 10 per cent faster than the roll speed so that the piece is kicked away from the rolls. This allows the rollers to spin under the bar which has the effect of a brake on the roller. With heavy bars that may be resting on only a few of the rollers, this often blows the motor fuses. Since this is common mill practice, it has been suggested that the group of motors nearest the roll stand be designed to run at a lesser speed than the main body of rollers, so that this excess load may be removed from these few motors. This suggestion is worth consideration, as practically all blown fuses are on the first half dozen rollers.

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The design of individual roller described by Mr. MacCutcheon has one advantage over the design with the external motor. This advantage occurs when the mill has a cobble and the crane is dragging it away. With the external motor, the cobble is often dragged or swung against the small motors sometimes causing damage. With the motor inside the rolls, this source of trouble would be eliminated.

A. C. Cummins†: My only experience with internal motor rollers is confined to one of the early experimental models. This roller was tested in our laboratory and tests were made which may answer Mr. Shoemaker's last question. A blow torch, in fact a couple of them, were turned on the roller, and as far as we could see it did not add much to the heat of the rotor winding, which of course corresponds to the stator winding of the ordinary motor. It would seem that the factor of heat can be taken care of.

J. R. Lewis‡: There is one point I would like to bring out on roll-out motor drive and that is, you should have a motor that is specially designed for the job. The ordinary motor will not do. There has been installations where the standard or general purpose motor has been used and this is a mistake!

The second point is to be sure you have the voltage of the roll-out motors the same as the shop bus of 220 volts for the top speed and the top voltage. The usual practice is to wind the roll-out motors for a lower voltage (say something like 83/137 volts) whereas we think it is preferable to wind from 137/220. This will allow the motors to run on the shop bus, in case of failure or shut down to the frequency M.G. set.

A. M. MacCutcheon§: The 2¼ second reversal time to which I referred was on a roller driven from a generator which was designed to supply the power for 12 rollers. In considering reversal, particular attention should be given to make certain that there is sufficient generating capacity available to reverse the number of rollers desired in the time desired. A very small set may be used for operating motor rollers when running continuously as compared with a set that would have to be used to secure a very rapid reversal. If 100 rollers are operated from a motor generator set and it is desired to reverse only 10 at one time, the capacity of the MG set will not have to be increased to secure a rapid reversal on these ten, but if it were desired to reverse the whole 100 rollers which are supplied by a certain motor generator set, the capacity of the motor generator set would be dependent entirely upon the demand at the time of reversal.

As regards the power factor, more data will be secured on this in the immediate future. The Power Factor is necessarily low since the motor within the roller has a relatively large number of poles and should have a reasonably large air gap. The matter of low power factor is of no moment as regards the other AC lines in the mill if the rollers are operated from a motor generator set. A large number of experiments have been made in connection with producing very high torque with a suddenly increased voltage just before reversal. The AC generator used in these experiments will take a very high over-excitation for a short period of time. Using the high voltage thus obtained, it was possible to reverse a roller 14" in diameter and 36" long in less than ½ of a second.

One gentleman made inquiry as to the torque which might be secured by special design. I would again emphasize that if sufficient electrical material is used, almost any torque desired can be secured. High torques can be secured by higher voltages. A sudden demand for a large torque may be met by a momentary increase in voltage of the generator. The most effective way to stop quickly is by the use of dynamic braking. When dynamic braking with DC introduced in two of the terminals of the motor roller was first tried, rather astounding results were secured. With 20 amperes of direct current introduced, the motor roller came to a standstill in considerably less than a second. The use of direct current for dynamic braking also stops the rollers very accurately as regards time. In other words, a group of ten rollers would all stop at approximately the same time.

As regards operating on shop frequencies, I think Mr. Lewis has brought out a very valuable point. The roller will operate indefinitely on a shop frequency and voltage if the desired feet per minute is secured by the number of poles that can be introduced into the motor roller and the frequency which is used in the shop. Under this condition, there is no speed control of the roller and on anything higher than 25 cycles, it is very likely that the desired feet per minute can not be secured.

As regards the question of heating, I think that Mr. Shoemaker's view exactly coincides with the view of every electrical man. Each electrical man asks himself whether it is possible to put a motor inside of a roller which is transferring hot metal and not have dangerous temperatures on the windings. To completely cover this question would take a very great deal more time than is at my disposal. I can only say that we find it quite surprising as to how effective the air passage is between the inner and outer shell to keep the outside heat from entering the motor portion. Tests made with hot metal on the rollers indicated a safe temperature inside of the motors. We expect in the next two months to have considerably more information on this point.

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The JUNE ISSUE of Iron and Steel Engineer will contain advance copies of all papers to be presented before the Annual Convention and Iron & Steel Exposition of the A. I. & S. E. E. In addition, lists of exhibitors, points and items of interest and other valuable information will be included.

HAVE YOU ARRANGED TO PRESENT A MESSAGE TO THE STEEL MILL ENGINEERS THROUGH THIS ISSUE? Forms close May 10th.

Atomic Hydrogen Arc Welding

By J. D. WRIGHT*

WITH the atomic hydrogen method of arc welding an alternating current is maintained between adjustable tungsten wire electrodes, and hydrogen gas is fed to the arc around the electrodes. The hydrogen molecules are broken up into atoms by the heat of the arc and in recombining outside the arc and in contact with the work, a temperature is obtained which is about one-third higher than that of the oxyacetylene flame. This heat is used to fuse the metals to be joined, and where additional metal is required, a filler rod may be fused into the work. The hydrogen gas keeps all oxides, scale and nitrides out of the weld metal, thereby giving a very ductile and machinable weld.

The equipment required for atomic hydrogen arc welding consists of a transformer for changing the voltage of the supply circuit to that required for the welding circuit; a variable reactor which automatically controls the current to start the arc and maintains the desired welding current; a control panel mounting the reactor and the adjustment for the reactor; necessary control; and an electrode holder.

The apparatus is designed to operate from single phase, alternating current, 60 cycles, at standard voltages up to and including 550 volts, with a current range of approximately 20 to 60 amperes.

It is not expected that atomic hydrogen arc welding will supersede straight arc welding or gas welding, but should considerably extend the field of application. Most of our work has so far been in the welding of alloy steels and thin metals. Some test data which I obtained this morning might be of interest to you. We were asked to weld by the atomic hydrogen process 3½" diameter tubes of alloy steel with a wall thickness of about 7/8", using the parent metal as an electrode to fill in the groove.

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Welds were also made by the straight arc in air and also by the gas process, with the following results:

	Tensile strength per square inch	Elongation in 2 inches
Parent metal	85,000 pounds	26%
Atomic weld	75,000 pounds	12%
Arc weld	55,000 pounds	2%
Gas weld	50,000 pounds	2%

High tensile strength of the deposited metal was desired and the above figures illustrate what was accomplished by the atomic process.

1/16" and 1/8" tungsten electrodes have been used, the former with about 25 amperes welding current and the latter with currents up to 60 amperes. The electrode consumption, welding continuously, is at a rate of about 1 1/8" per hour, using 1/16" electrodes and 25 amperes and about 1½" per hour using 1/8" electrode and 60 amperes.

The input to the equipment with 25 amperes welding current is about 7½ kv-a. and with 60 amperes welding current the input is approximately 18 kv-a. The power factor is rather low, as the kw. input corresponding to 18 kv-a. is approximately 7¼ kw.

Speeds which can be obtained by hand welding are indicated approximately by the following: When making an edge-weld on 22 gauge metal we have obtained speeds of 7½" to 8" per minute. On 11 gauge, using 1/8" electrode and 35 amperes we have obtained welding speeds of 5½" to 6" per minute.

At the present time equipment is available only for hand welding. A study is being made of applying the process to automatic welding but many problems are involved and commercial equipment is not yet available.

Electrical Safety Circuits—Their Uses and Construction

Original paper presented before Philadelphia Section of A. I. & S. E. E., by Mr. W. M. Runyon appears in December, 1927 issue of Iron & Steel Engineer.

George J. Walz*: There are not so very many details that are still clear in my memory from the time I first started to work in the electrical department of a Steel Plant, over thirty years ago, because I was then only a young boy, but there is one thing that does still stand out most prominently above everything else, and that is that never-to-be-forgotten feeling I had, whenever I took hold of a supposedly dead bare high-voltage line, to work on it. A high-voltage line then usually meant a 2200 volt circuit, which doesn't sound so wicked in these days of transmission voltages running up to a hundred times as high, but which, with a good contact, will, of course, kill a man just about as quickly. But in those days there was absolutely no thought of safety, there were no safety devices whatever—the Foreman often ordered you to do this dangerous work, when you knew that there was no positive certainty of the line being dead, partly due to the fact that there were no telephones on the plant, and

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naturally there were many accidents and still many more narrow escapes, for men were encouraged and sometimes even forced to take long chances and recklessness was then considered a valuable attribute in any man.

Fortunately today, all of this is entirely different,—most employers will not allow a man who is careless with his own life, or that of his fellow-workers to remain on the payroll and there appears to be no limit, and rightly so, to the millions upon millions of dollars that are being spent annually to prevent accidents.

Now, the one single factor which was most instrumental in bringing about this radical change in our industrial conditions during the relatively short span of one generation, I am happy to say, was the A. I. & S. E. E. This organization was the real pioneer of organized industrial safety in this country and it was under its direct auspices that the National Safety Council was organized some years ago. This National Safety Council was the means of creating a great deal of interest in safety work in State and even Federal Agencies and it is mainly as a direct result of its activities that most of our states now compel employers by law to install certain safety devices and enforce certain safety measures.

But the spreading of the Gospel of safety as well as the development of improved safety devices is the one work above all others, which can be truthfully said to be never-ending. We can never afford to sit back and rest, complacently satisfied with what has been accomplished, for that would be merely deceiving ourselves with the delusion of a fancied security, very much like the Irishman, who had the misfortune to fall off the scaffold on the 15th story of a building on which he was working and who, as he went past the 10th story, was heard to say to himself, "Well, so far I'm all right."

So it is directly in line with the Association's policy of always attempting to keep abreast with any and all safety developments, that we have selected the theme of the paper, for this evening, for there has lately come into use a new system of wiring, with which it behooves all of us to become thoroughly familiar, for it is my understanding, that some states have already begun to enforce the use of this system of wiring, by law.

Mort. B. Gleason*: I do not know just what is left for me to say on the grounding question. I think it has been pretty well covered by Mr. Runyon as well as by Mr. Canada. What Mr. Canada has told you would be considered national; anything I might say would have a feeling, probably, for just a local condition.

In Mr. Runyon's remarks I took particular note of what he said about what happened in New Jersey. Now that same condition can happen to any of you men in any industrial plant. The conveyor was an eight-wheel affair, but had been grounded; but due to rust, etc., on those wheels, broke down the possibility of that working ground, with the result that one man got hooked, another man in trying to save him got hooked, then along came the electrician. Now had that electrician exercised the proper function, and put the key for that particular panel box where it should have been kept, the other man probably would have been saved. But the result was he had the key in his pocket, and the fourth man in trying to get the key got shocked. In some manner they broke the circuit, and the result was the fourth man, while not fatally injured, was burned badly. That may be a good lesson for any of you men in industrial plants to put those keys in an accessible place where you can use them for the safety factor they are intended for.

The grounding question from an underwriting standpoint has come to be a very big one. I might say particularly on the artificial ground in many places and localities we have no way of getting such a thing as a driven ground due to stone foundations, etc. Through our coal regions, we find that where a driven ground is made the life is very short due to the sulphuric action. Another phase from an underwriting standpoint is in some industrial plants where they have devices that can be used, and should be used to get proper grounds, they simply won't use them for the reason they will say it is expensive. They resort to making some artificial device that has a tendency for making a very loose contact, and the result is when it comes to looking for proper ground function there is no ground to work on. This is a question that has been given a great deal of thought. The Grounding Committee has been working on that particular subject for the past two years. They have devoted a great deal of time, and time very well spent considering the progress that has been made in that particular committee.

I feel perfectly satisfied that if you gentlemen who have occasion to use grounding will follow the lines the Code describes you are going to help yourselves and everybody that is interested in the grounding question.

Robert M. Nesbitt*: In accepting your kind invitation to meet with you on this occasion, I did not know I was going to be called on to say anything. However, after hearing these very able speakers discuss a subject which I know they have given considerable attention I cannot resist saying a few words.

The subject of grounding has been a very interesting one to me for a number of years and it seems to be growing in general interest because one hears so much of it lately. Only a few Saturdays ago after having been detained at my desk reading something on the subject of grounding, I returned to my home and for a little diversion tuned in our friend, Graham MacNamee. I was getting quite a "kick" out of his inimitable manner in describing the progress of a football game. Everything was going along nicely and I was enjoying his word picture when all of a sudden he said something about one of the players making a forward pass but that the pass was not completed, the ball having been grounded on the 20-yard line. This brought to my mind the subject of grounding fixed and portable electrical equipment which is of such great interest today and which is receiving so much discussion pro and con as to insulation vs. grounding, and if grounding is done, how? Probably this also exists in the football game,—a difference of opinion between opposing teams. Undoubtedly one side is quite desirous, under certain conditions, of greater insulation being

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*Electrical Dept., Philadelphia Fire Underwriters' Assn

placed on the football, the other side making every effort to obtain permanent and effective grounding.

Mr. Runyon no doubt has painted, technically, a perfect picture in the diagrams shown, but everything that works out with technical and laboratory niceties does not always work out in practice.

My mind is very much open as to further grounding rules beyond those given in the 1925 edition of the National Electrical Code. I am here tonight to listen and to learn, but as I view the subject of grounding in its general scope the method pursued in grounding cannot be too good, and as I see it extension to Code regulations on the subject must embrace economical factors and local conditions where initial, effective grounding may be obtained and properly maintained.

I do not think that I need say more at this time and desire to thank you for having me with you on this most interesting and enjoyable occasion.

H. B. Praett*: I cannot add anything to what has been given by Mr. Runyon, Mr. Canada and Mr. Gleason. The only thought I have in mind from the standpoint of the utility and the contractors is the suggestion that Mr. Gleason has brought out, that some contractors will attempt to use makeshifts for the ground bushing, and with these makeshifts you can not secure the grounding connection you should have. If we are going to go through with polarized wiring, let us do it in the proper way and use a standard grounding bushing.

I would like particularly to call your attention to the grounding around the water meter shown in this picture. This should be absolutely tight and the surface underneath the ground clamps should be absolutely clean where the contact is made. Many times wiremen clamp the ground strap around ordinary pipe without any attempt to clean the pipe and expect to have a perfect return circuit.

D. M. Petty†: This meeting to my mind is a very happy one. Our speakers put their speeches across very well, and I am also inclined to believe there was a good deal of collusion among some of the speakers, because Mr. Runyon came down to see me not very long ago and I told him one of my little hobbies, but he did not want to discuss this topic, so he arranged with Mr. Canada to cover this subject. The subject in question is about grounding one side of 250 V. D.C. power systems. I have been making a little study of that rather quietly. I wanted to see what we could do with third rails and electric locomotives in our transportation system around the plant. I decided it would be quite an advantage if one side of our system could be grounded, so we grounded one side of one of our D.C. systems. I picked out the smallest one, about 1500 k.w., we went out to the end of the feeders and grounded them all. They have been running this way ever since, about four years, and we have had no trouble. So we have made preparations now to ground all our D.C. systems throughout the Lehigh Plant. Primarily we wanted to connect the third-rail system for railways directly to our D.C. shop circuits, but since we grounded one side we have found a lot of reasons why grounding one side of the line is a good thing.

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†Elec. Supt., Bethlehem Steel Co., Bethlehem, Pa.

The idea of grounding one side in color cord is a good thing. At first I was under the impression there was a little collusion on the part of the wire people, but I think possibly it will work out all right.

I think we should give a great deal of thought to portable tools. Being carried around the plant, the men are subject to sudden shock, and are liable to get hurt in a fall, if not from the shock. If such a shock can be prevented it is a good thing.

I will let you in on another secret. I have from time to time casually asked a great many of the older pioneers in the Steel industry all over the country if their D.C. systems were grounded, and the answer was that they were. In one particular instance, when I asked which side was grounded I was told they didn't know as they had not yet found the ground. I asked another man the same question and he said, yes, it was the negative side, and when they wanted it grounded on the positive side they just switched the leads! That is the answer I found everywhere. I have not found anybody yet who did not say their D.C. system was grounded. I think the Fire Underwriters and Safety men will agree it is much better to have the ground on one side of the line and make the other side ungrounded. I feel that the question of grounding one side of your D.C. circuit is a real problem. I believe we can get a great deal of help from the street railway people; they have had considerable experience in that sort of thing. The first job I ever had was with a railway company working under a car, cleaning the grease off the motors, and some fellow put the trolley pole on the wire. They told me it was only 500 volts, but I was pretty sure I'd had a shock.

George Pfeffer*: Most of our trouble is grounded wires we never can clear along the D.C. system.

I believe a good bit in what Mr. Petty says: We can run one side grounded. I would like to hear a little more discussion on that.

Chas K. Steinmetz†: I came here primarily to see what was going on in the matter of grounding in the steel industry, not to make any speech.

Grounding is so obviously the thing to do, it seems to me the only discussion necessary is the manner of grounding, particularly having in mind alternating currents. Direct current grounding is the thing that must be handled carefully, of course.

In the utility game the safety standpoint of the human being is of course very important; but one should bear in mind there is a general tendency perhaps to a duplication of wiring. I am referring to house wiring. In the steel or industrial world considerably more money can be put into the thing.

In my experience, I would say have your wiring thoroughly tested. Do not try to establish or feel you have a ground unless you are sure of it. Carefully study the installation. There is no chance for high voltage when you have a protected grounded system.

G. G. Shannonhouse‡: I have very little to say after having listened to Mr. Canada's remarks and

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also Mr. Runyon's, but I would like to say this. We have been for some time very much interested in grounding, and about three years ago we started grounding all of our plants throughout. But there is one thing I have not heard any one discuss yet and that is the grounding of three-phase circuits, and I would like to hear some discussion on that. We have adopted that practically in most of our plants and it has proved very satisfactory so far.

I certainly have enjoyed being here tonight and hearing this paper and the discussions.

M. H. Holz*: I do not know as I can add anything to the discussion, but it just came to my mind when one of the gentlemen spoke of the one-wire circuit, that we will have to get a simplified method to take care of the double pole switches on the circuit and the single pole switches. A third wire adds to the cost and competition of wiring. Whether that can be carried on three-phase stuff, of course, is another proposition, but it seems to me you will have to work out something to solve the circuit wiring before you get the proper solution of the question. When you add anything there is always an increase in the cost. That is just by thought—we will have to simplify rather than add to the wiring cost.

L. S. Ballau†: I came here as some of the others have already stated, to learn something relative to the practices of grounding electrical circuits for safety purposes rather than to add to the discussion. The widespread use of portable electrical equipment in the steam railroad field is on a whole only a relatively recent development and, therefore, the subject of the so-called safety wiring is one of extreme interest.

While I am heartily in accord with the principle that in electric wiring practices every reasonable precaution should be taken to insure safety both with respect to protection against shock as well as reduction of fire hazard, I feel that in considering new devices and detail practices to accomplish these results we should proceed carefully. I am in full accord with the practice that more effective means than now used should be employed to insure proper grounding for safety purposes of portable equipment, etc. On the other hand, I am in sympathy with the viewpoint taken by some of those who have spoken on the matter that we should proceed cautiously with the suggested practice of providing a third wire in portable extension light service, particularly when with modern wiring practices one side of the lighting circuit is already grounded.

I am very much interested in the subject of applying this grounding practice to low voltage 3 phase power circuits. We are using 440 volts as a general standard for our 3 phase power service, but for portable equipment prefer to limit the voltage to 220 volts. Where a pendant type of push button control equipment is used we are finding it good practice to limit the voltage on the control circuit to 110 volts, as we feel the use of 440 volts with the ordinary design of push button station where connected to the main control equipment by means of a flexible cable is more or less hazardous unless very special means are taken to insure proper grounding.

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George J. Walz*: We have this 440 volt problem at our plant which Mr. Billau has referred to, and we have a safety measure there that only partially takes care of it. The 11,000 volt transformers are Y connected on the low side—the 440 side—and the Y point is grounded. That gives you 254 volts between one of the lines and the ground at any time. Now that is not any too safe a voltage when you consider the maximum of the voltage wave goes considerably above 254 volts, but we have not found any other effective way of taking care of that.

C. M. Thompson†: This question of grounding is very interesting to me. One point particularly which Mr. Runyon brought out is the use of the extension lamp. I might say we have prohibited the use of extension lamps on inspection of boilers, using a hand battery lamp. We do not permit any fireman or inspector to use a portable lamp other than the battery lamp.

Most of the discussion has been on D.C. and three-phase. Unfortunately we are in a district where we have the old two-phase system. One of our greatest troubles is clearing grounds rather than placing grounds on the system. However, I believe the grounded system as discussed here tonight will cut down the loss of lamps on lighting circuits. That is a serious problem we have in our own plant, and I believe this is another phase besides safety.

I would like to hear some discussion on the two-phase, four-wire system of distribution with relation to grounding.

D. M. Fuller‡: There is hardly anything more I can add to what the speakers have said.

I think it is the dream of engineers for utility companies to have a network of grounds extending from the Atlantic Ocean to the Pacific Ocean, so we can reach out at any time and get a good ground. This matter of grounding has been and is being given a lot of thought by the company by whom I am employed, and we have got a lot to learn.

One of the questions that came up some time ago was the question of grounding men. The speakers before have spoken of grounding apparatus and lamps and everything else, but this question of grounding men. Maybe if we could ground the men we would settle everything. I never realized it could be done until I came to the meeting tonight, and the man beside me said, "If I had only one more drink I would have been grounded." Maybe that is the way to ground the men.

There is just one or two matters that we have had to give a little consideration. They are the question of grounding 220 volt and 440 volt three-phase circuits. We got ideas from the National Electric Code on the 220 volt circuits, but the 440 volt proposition we had to give up. Perhaps some day they will give us some idea of how to do that. Perhaps they have done so already, but we could not find it in the book.

Albert F. Edel§: I came here this evening to learn more how to bury a ground than to praise any

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particular method of grounding. I have picked up quite a few points. The only thing I want to add is the general principle we follow around plants; that is, we aim to get a well-distributed ground, a continuous ground, and a ground of low resistance. As pointed out, pipes about ten feet apart will give a well distributed continuous ground, and usually one of low resistance. Some of you who have large sub-stations or plants probably appreciate the value of that. Sometimes you are apt to get a dangerous gradient in the vicinity of a plant, and we keep the ground as low as possible.

I was much interested in the grounding on the water pipe shown in the sketch. We use corporation cock for a connecter, drill the pipe and screw this tap into it. In all cases the water companies have been willing to co-operate with us on this point. It is a most effective way of getting a good ground.

That is about all I have to say on the subject, which has been pretty thoroughly covered this evening.

J. R. Penman*: I do not think I can add anything to the subject.

But speaking of grounds, most of our plants are using 250 volts D.C., and on the switchboard we have the usual method of detecting grounds with two 250 volt lamps in series across the line and a connection from between the lamps to the ground. The electrician very frequently finds it necessary to remove grounds from one side or the other.

One of our plants outside of Reading where they do not employ an electrician, but leave the motors in care of the general handy man, this plant seemed to have less trouble with the grounds showing up on the lamps than where we had an electrician. Until one day we had a hurry call for an electrician, they said every time they tried to run the crane the main breaker of the power house went out and shut the plant down.

Our electrician learned that they had a good ground on the crane on one side and in some other part of the mill a good ground on the other side, but the ground lamps did not indicate that there were any ground at all. The general handy man had learned that if he cut the wire of which lead to the ground from between the detector lamps, he had no more trouble with one or the other lamps showing a ground.

W. M. Runyon†: I have made a few notes here, and some of these questions I can answer, and if I cannot, I am going to call on whoever I think can. I would rather Mr. Canada would answer the question of using the grounded wire of the circuit for a ground. I believe he is in close touch with that situation.

Mr. Gleason brought out the question of artificial grounds. Keeping them at a low resistance is a hard job.

There is one point shown on sketch I did not bring out before, but very often it will help some. In a case of this coal conveyor, this grounding connection to plug as shown here furnishes a good method of grounding—if you have no water line available it is necessary to get to an artificial ground, or get back to where you have a water line. You most always have a water pipe somewhere back at the sub-station or Power House and it is comparatively a cheap job to run your wire through the air. By so doing you can get a low resistance ground, much lower than what the driven ground furnishes. This method of grounding has been used in several large chemical plants with very good success.

This print, as Mr. Nesbitt justly says, looks all right on paper. I hope it does. All I have attempted to do here is to picture grounding as it should be done, and hope you can wire as near as possible to it. This print is more or less drawn to bring out a lot of those features of how to ground, and what is recognized as good practice.

Mr. Pratt brought out one question I skipped over a little too quickly, I think. The question is often asked: Why use this meter shunt? If you do not get this clamp ahead of the meter you are supposed to shunt the meter. There is a rubber gasket on each side of the water meter which are good insulators and poor conductors. The shunt is a copper welded steel wire, which gives you both electrical and mechanical protection furnishing a complete metallic path to ground.

Mr. Petty brings up the question of not using that third wire for grounding protection on portables. I will ask Mr. Canada to answer that later. There is one point in connection with that question that I can answer. Mr. Petty stated he had one side of the system grounded, and a lot of the rest of you have. That being the case in your 220-volt lighting, it is very easy to work in polarization so far as your lighting is concerned, etc., by simply finding just which is your ground wire and connecting it to the white shell socket terminal. All new sockets are so marked.

The suggestion about the railway people helping you out regarding single wire ground return I think is a good one. They have had more experience on that class of wiring than anything else.

To Mr. Shononhause's (of the DuPont Co.) remarks I might add that as far as his company is concerned, I have had more or less dealings with your many plants, and I might say there is no industrial company I know in the eastern half of the United States that has gone as far into this question as they have. Of course they are handling hazardous material, in some cases, and for necessity they looked into it long before a lot of the rest of us did. I think they have used this form of apparatus so wired with very good results.

Mr. Canada will answer your three-phase ground question. I am not in a position to answer it properly.

Mr. Holz' suggestion of trying to simplify wiring is very good and we are all with you as long as real results are obtained and the shock-hazard is reduced.

The reason we have gone to this type of wiring using an additional wire on portables is because the N. E. C. local, state and labor codes have gone to it after trying them out and obtained good results. That answers your question in a way, Mr. Billau.

In regard to Mr. Thompson's question relative to two-phase four-wire system grounding I am asking Mr. Canada to answer.

The same for Mr. Fuller.

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*Reading Iron Co., Reading Pa.

†Engineer, Grounding Division, Crouse-Hinds Company, New York, N. Y.

Mr. Edel, I might say your remarks brought up a thought some of us know about and some do not. I skipped over this unintentionally; but for a period of the last five years the power companies realized this question was an important one, have been grounding their new sub-stations, power houses, and apparatus as a whole, and have been using special driven points in the ground—in some cases as high as thirty to fifty points connected together by heavy bare copper cable. The question of how good that ground is is a mighty important one. There are companies making periodical resistance tests of this apparatus regularly. You will find suitable meters for testing listed in the different trade magazines.

The question of grounding into the water companies' line, which Mr. Edel brought out, is a good one. Some time ago the water companies did not like to let the electrical companies use their water lines. I might say today that feeling is fast passing away, and they seem to be co-operating very well. At the Atlantic City N. E. L. A. convention a consulting engineer for Toronto, Canada, told me they had just ordered a power company to hook fast to the water feed line for grounding. So you see that co-operation is coming along quite well.

That is all I can add. I am going to ask Mr. Canada to bring out the other points. If I can be of any service to you at any future time, I would be glad to have you call upon me.

W. J. Canada*: I presume Mr. Runyon left these two or three questions partly to me because he felt I was quite sure to get into difficulties with them.

With regard to the 3 phase circuit, why does not the National Electrical Code deal with the grounding of the circuit, or deal with the grounding of the equipment? Ever since 1913 the National Electrical Code has permitted the grounding of 3 phase circuits of any kind—220 or 440 volts. A good many have thought it should be required, but there is a serious difficulty in the way of recommending such a practice, unless you are able to say under what conditions the grounding should be done. In my own judgment a 220 or 440 circuit should be grounded. A 3 phase delta circuit can be grounded at any corner. It is better to ground it on the phase wire because the phase wire is always there. If it is a circuit somebody is trying to make work double just for so-called wire economy,—trying to use one phase for lighting,—that is an application I might say that was very popular at one time because it saved the first cost in wire. However, that popularity is waning because it was not a particularly good system. A 3 phase star system is easy to ground, whether voltage is 110, 220 or 440. I believe that the tendency of good practice and of the Code, is toward grounding of all A.C. interior wiring systems supplied through transformers or exposed to higher voltages than their own.

As to grounding the equipment, most companies believe that all 440 volt, 3 phase equipment should be grounded. I presume nobody is questioning the advantage of it. It was formerly the practice to hook up the frame with a wire running to the nearest water pipe and to hope that this hit or miss ground connection would stay in place even though exposed to all kinds of vicissitudes. In time, however, we found it was necessary to add a more orderly grounding medium as the better form of grounding for equipment frames. As we began to use more conduit, more metallic cable, metal raceway, etc., we began automatically to provide ourselves with a good grounding medium, and for that reason the motors today, being mostly connected to these forms of wiring, have automatically been getting better grounds, and grounds which stay in better shape.

As to the portables using one wire of a circuit, to ground their frames—theoretically and conjecturally the use of a circuit wire, picturing it as part of one common network is very fine, but it leads into many difficulties. It is because of some of these difficulties that the association water companies, at the Atlantic City meeting this last year, passed a resolution withdrawing their general approval of grounding to water systems. Of some of these difficulties I have already spoken in my prepared discussion. I will discuss some others as briefly as possible.

Somebody has said he would like to ground the man. This proposal has merit for iron men. So long, however, as he remains a merely flesh and blood individual, it is a rather dangerous thing for a man to lift a portable off the ground and handle it unless he is pretty sure of the grounding of the frame of the portable. In domestic locations, where he has only a few grounded floors and grounded fixtures, and has low voltages, everything is in his favor to omit all grounding and depend on the apparatus insulation not breaking down while in contact with somebody. When you begin to use a circuit wire for so-called grounding of a portable frame, either you immediately have made it alive or made it grounded, but the frame is no longer insulated. You are no longer depending on, or protected by, the insulation from circuit parts to the frame.

Suppose we consider portables used in a city where the usual practice and usage is to utilize a two phase, four wire circuit which is not grounded at all. As soon as the connection of a circuit wire to a portable frame is made in that city the user immediately has a live wire connected to his apparatus. There are numerous vicissitudes which may happen to the circuit wire, even where it is assumed to be grounded which do not happen to the third wire in a cord or wiring system. The third wire is not subject to much disturbance and to none at all by design. But this circuit wire which would supposedly be connected normally to a frame is subject to all kinds of vicissitudes.

We are not getting away from simplicity in our wiring system, by using a third wire in portable cords and in non-metallic forms of wiring. This development toward required grounding of equipment has grown very rapidly in recent years. It has become so much of a question, and so many injuries have occurred, that state after state, through its industrial department; city after city, through its municipal department, and the Dominion of Canada as a whole, through the recent action of its Canadian Engineering Standards Committee, have called for the grounding of many portable as well as of most fixed equipments. The current development of practice in this country has arrived at the point where the next issue of the National Electrical Code may

*Elec. Field Secretary, National Fire Prot. Association, New York City.

probably require that portables shall be grounded in industrial establishments or where above 150 volts. In other establishments the grounding below 150 volts may well rest for a season.

The necesesary plugs and receptacles for grounding by a safety ground-conductor are being developed; the cords now exist; the cost cannot be considered considerable; the simplicity is all in its favor, when one thinks of the vicissitudes which one saves by having a sure ground or no connection at all to a frame, as against a so-called ground, which may be a hazard at times instead of the safeguard which the user has a right to expect that we engineers will provide for him.

As your Chairman said earlier in the evening, we have to move rather fast to merely keep with the progress of events. I am always reminded when that sort of a statement is made of Alice in the Looking Glass, where the White Queen asked Alice to take a little journey so that they might get somewhere. She took Alice's hand and they just whisked through the air. When they paused, Alice out of breath, they were just where they were before. Alice was disappointed and asked why they hadn't made any progress. The Queen replied "This is a strange country. Here we have to move mighty fast just to avoid falling behind. We would have to go twice that fast to really get ahead."

I think this electrical industry and its attendant safety problem has grown so fast that we, perhaps have not kept quite up with it in our efforts to reasonably safeguard this rapid development.

As I looked at the drawing that Mr. Runyon so well described, it appeared to me that this is one of the clearest statements and illustrations that I have ever seen.

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*Iron Ore Industry Records Decrease in Output and Value in 1927**

THE iron ore mined in the United States in 1927, exclusive of ore that contained 5 per cent or more of manganese in the natural state, is estimated by the United States Bureau of Mines, Department of Commerce, at 61,778,000 gross tons, a decrease of 9 per cent as compared with that mined in 1926. The ore shipped from the mines in 1927 is estimated at 61,325,000 gross tons, valued at $153,641,000, a decrease of 11 per cent in quantity and of 12 per cent in total value as compared with the figures for 1926. The average value of the ore per gross ton at the mines in 1927 is estimated at $2.51; in 1926 it was also $2.51. The stocks of iron ore at the mines, mainly in Michigan and Minnesota, apparently increased from 9,565,880 gross tons in 1926 to 10,044,000 tons in 1927, or 5 per cent.

The Bureau of Mines estimates are based on preliminary figures furnished by producers who in 1926 mined about 99 per cent of the total iron ore. They show the totals for the principal iron-ore producing States, and, by grouping together certain States, the totals for the Lake Superior district and for groups of Southeastern, Northeastern, and Western States.

Lake Superior District

About 83 per cent of the iron ore shipped in 1927 came from the Lake Superior district, in which approximately 51,691,000 gross tons was mined and 51,183,000 tons was shipped, decreases of 10 and 13 per cent, respectively, a scompared with the quantities mined and shipped in 1926. The ore shipped in 1927 was valued at $130,453,000, a decrease of 14 per cent. These totals include the ore from mines in southern Wisconsin and ore shipped by rail as well as by water from all mines, but exclude manganiferous ores amounting to approximately 1,302,000 gross tons in 1927 and 1,065,419 tons in 1926 that contained 5 per cent or more of manganese in the natural state. The ore is chiefly hematite. The stocks of iron ore in this district apparently increased from 8,208,713 gross tons in 1926 to 8,759,000 tons in 1927, or 7 per cent. The stocks at the end of 1927 were about 655,000 tons less than the average for the preceding five years. The shipments of iron ore by water from the Lake Superior district in 1927 (including manganiferous iron ores), according to the Lake Superior Iron Ore Association, amounted to 51,107,136 gross tons, a decrease of 13 per cent as compared with these shipments in 1926. The average value of the ore at the mines in the Lake Superior district in 1927 was $2.55 a ton; in 1926 it was $2.56.

Southeastern States

The Southeastern States, which constitute the second largest iron-ore producing area, including the Birmingham and Chattanooga districts, mined approximately 6,832,000 gross tons of iron ore in 1927, a decrease of 5 per cent as compared with 1926. The shipments of iron ore from mines in these States in 1927 amounted to 6,866,000 gross tons, valued at $14,016,000, decreases of 5 and 7 per cent, respectively, in quantity and value as compared with 1926. The ore is mainly hematite; brown ore and magnetite come next in order. The average value of the ore produced in these States in 1927 per gross ton was $2.04; in 1926 it was $2.07. The stocks of iron ore at the mines in this group of States, mainly in the Birmingham district, decreased from 941,260 gross tons in 1926 to 907,000 gross tons in 1927. These stocks are about 209,000 tons more than the average for the preceding five years.

Northeastern States

The Northeastern States, which include the Adirondack district, New York, and the Cornwall district, Pennsylvania, in 1927 mined 2,248,000 gross tons of iron ore and shipped 2,269,000 tons, valued at $7,649,000, increases of 16 per cent in quantity mined, 16 per cent in quantity shipped, and 19 per cent in value of shipments as compared with 1926. The stocks of iron ore in this group of States de-

*Furnished by Dept. of Commerce, Washington, D. C.

creased from 403,742 gross tons in 1926 to 366,000 tons in 1927. These stocks are considerably less than usually carried over at these mines, being about 201,000 tons below the average for the preceding five years. The average value of the ore in these States in 1927 per gross tons was $3.37; in 1926 it was $3.28. Most of this ore is magnetite.

Western States

The western States that ordinarily produce iron ore named in order of their importance are Wyoming, Utah, New Mexico, Colorado, Montana, and California. Occasionally Idaho, Nevada, and Washington contribute small quantities. All the ore from Wyoming, New Mexico, and Colorado and most of that from Utah is used for the manufacture of pig iron. Much of the remainder is used as a flux in smelting copper and the precious metals. It is estimated that the Western States mined and shipped in 1927 approximately 1,007,000 gross tons of iron ore, valued at $1,523,000, decreases of 15 per cent in the quantities mined and shipped and 12 per cent in value of shipments as compared with 1926. The ore comprises hematite, magnetite, and brown ore.

Imports and Exports

The imports of iron ore reported for the eleven months ended November 30, 1927, amounted to 2,488,871 gross tons, valued at $5,730,852, or $2.30 a ton. The imports for the year 1926 were 2,555,441 gross tons, valued at $5,876,316, or $2.30 a ton. The reported exports of iron ore for the eleven months ended November 30, 1927, amounted to 897,282 gross tons, valued at $3,418,475, or $3.81 a ton, as compared with exports for the entire year 1926 of 868,710 tons, valued at $3,380,701, or $3.89 a ton. These statistics of imports and exports were compiled from the records of the Bureau of Foreign and Domestic Commerce, of the Department of Commerce.

The following table shows the quantity and value of the iron ore mined and shipped in the United States by the principal producing States. The figures for 1926 are final, but those for 1927 are subject to revision.

Estimates of iron ore mined and shipped in the United States in 1927 and actual output in 1926.

District	Ore mined (gross tons)		Ore shipped			
			1926		1927	
	1926	1927	Gross tons	Value	Gross tons	Value
Lake Superior:						
Michigan	15,248,254	15,023,000	16,699,984	$ 43,932,982	14,685,000	$ 37,757,000
Minnesota	40,701,613	35,398,000	40,961,361	103,715,621	35,558,000	90,289,000
Wisconsin	1,322,776	1,090,000	1,238,885	3,178,156	940,000	2,407,000
	57,272,643	51,691,000	58,900,230	$150,826,759	51,183,000	$130,453,000
Southeastern States:						
Alabama	6,847,789	6,473,000	6,871,412	13,846,656	6,505,000	13,021,000
Georgia	51,642	50,000	51,642	149,198	50,000	136,000
Missouri	124,371	83,000	124,371	532,536	83,000	369,000
North Carolina	15,198	33,000	14,798	31,645	33,000	82,000
Tennessee	138,819	124,000	138,307	312,109	124,000	279,000
Virginia	49,159	69,000	49,703	162,446	71,000	129,000
	7,226,978	6,832,000	7,250,233	$ 15,034,590	6,866,000	$ 14,016,000
Northeastern States:						
New Jersey	209,117	219,000	212,152	925,403	198,000	834,000
New York	638,849	850,000	659,741	3,015,586	939,000	4,276,000
Pennsylvania	1,095,505	1,179,000	1,088,634	2,483,056	1,132,000	2,539,000
	1,943,471	2,248,000	1,960,527	$ 6,424,045	2,269,000	$ 7,649,000
Western States	1,179,908	1,007,000	1,181,842	1,730,251	1,007,000	1,523,000
Grand total	67,623,000	61,778,000	69,292,832	$174,015,645	61,325,000	$153,641,000

*Combustion Control and Regulation**

By J. F. SHADGEN†

I WISH to thank you for the opportunity to open the discussion on the subject of control and regulation.

To familiarize the audience with the development in this branch of engineering, it may be interesting to review the progress of the last ten years. At first control problems were sneered at and solved individually in a haphazard way. Speed control of engines, turbines and prime-movers was the only serious field of application.

Since 1918-1920 refinements in plant operation became ripe for substitution of men by machines in the fields of pressure and flow, and a marked activity started along broader lines.

The first step was the development of reliable regulators with universal adaptability of all problems such as suction, pressure, voltage, speed and flow. It took several years to work out the practical difficulties. Two lines of thought were available, the electrical way or the mechanical way.

The Smoot Engineering Corporation concentrated on the application of mechanical regulators, because they give the best results with heavy forces of correcting devices, and because of the ease of adjusting them in the field by the available operators.

Electrical regulators have their field of application and are suitable in their line.

During the years of 1922-1924 the increasing markets demanded reliable and interchangeable ma-

*Presented before Pittsburgh Section, December 17, 1927.

†Engineer, Smoot Engineering Corporation, 136 Liberty street, New York City.

chines. This condition created the problem of production, as the manufacture of 50 to 60 regulators at one time was a problem in itself, just as much as the making of one automobile is different from the making of 100 automobiles.

Today a number of concerns are offering reliable and interchangeable regulators, provided with hand control devices, which permit instantaneous change-over from hand to machine operation. This feature is important from the practical point of view to increase the confidence of the plant operators in the new equipment.

The second phase of development was entered into about 1923-1925 by the marketing of **systems of regulation,** and combustion control offered the first field of immediate importance. The burning of fuel is a complex problem affected by two, three or four variables which require co-ordination and separate adjustment, etc. Public utilities desiring to reduce their fuel bills encouraged the efforts along this line, and today from 60 to 75 large and small boiler plants are operating under machine or automatic control, maintaining close steam pressure regulation and good monthly efficiencies.

For instance, the Kent Avenue Plant of the Brooklyn Manhattan Transit Company operate seventy-two 600 h.p. boilers as a harmonious unit, taking the load swings due to the running of subway trains. At the Hudson Avenue Plant of the Brooklyn Edison Company twelve 2,000 h.p. boilers and four 2,000 h.p. boilers are run at 300 and 400 pounds pressure respectively, and complete co-ordination is secured by a remote control board. Operating results of the last year are considered remarkable and credit is largely given to the combustion equipment.

A number of gas plants with water gas sets and violent load swings for three to five minutes have found in the control equipment a means to raise their boiler performance above the average. All kinds of fuels and burning equipment such as underfeed stokers, chain grate stokers, pulverized fuel, etc., have been adapted to machine control.

In conclusion, I wish to make the following point:

Control equipment is only a tool in the hands of an operator. It is impractical to expect to operate a furnace or boiler from a point several miles away from the plant. Boilers and furnaces are operated by the man on the floor. The management has to subdivide the task of the man so that he can specialize on his own job and thus properly co-ordinate all his tasks. Control offers an ideal means to achieve this aim.

It removes from the operators the repetitive duties which have to be executed thoughtlessly, and by doing this it allows the operator more time to use his own judgment. The most encouraging side issue of the application of control we have found to be the development of an "engineering sense" in the operating crews. The elimination of the entire physical exertion creates a better atmosphere which is always translated in better operating results. If the management is disinterested, results are not what they would be because the attitude of the management is transmitted to the operator.

It is most gratifying to state that automatic control improves the work of the man by giving him more time to think and less chance to become tired.

In the steel business where the combustion problems are intermingled with metallurgical operations, there is a good opportunity of applying control to furnaces. Machine control will allow the man to concentrate on the most important feature of his work and in this way increase his effectiveness.

From the development work in boiler rooms, it is safe to say that similar improvements can be obtained in metallurgical furnaces, provided equipment manufacturers and industrial engineers are given a chance to co-operate and work out the practical application.

DISCUSSION

W. P. Chandler, Jr.*: The regulation field is very broad, and as Mr. Shadgen has more or less touched on boiler regulation, I will confine my remarks to industrial furnaces. For the last year we have been specializing on the large fuel users in the steel industry, especially open hearth furnaces and billet heating furnaces. There is a great necessity for automatic control in both of these places. Most of the first helpers, or men that run the open hearth furnaces pay more or less attention, as they tell you, to regulation of the air and the stack draft, but sometimes they know and sometimes they don't know what to do and very seldom do they know why they go through certain actions. I have heard time and again, a man say that the furnace is getting too hot, and shut off some air to cool the furnace. Our work with automatic control has been primarily to proportion the amount of air that is used in combustion to the fuel that is being burned. We wish to give the operator a better tool to work with. He is the best judge at the present time of the amount of fuel the furnace requires. Application of automatic control in the steel mill is entirely different from central boiler house practice. Delays occur in rolling mill operation which necessitate holding the furnaces. The various grades of steel require different handling, and at the present time no direct method has been found reliable enough to supply fuel to the furnace automatically; so that the thing we have striven for was to allow the operator to supply the fuel to the furnace as it is desired, and automatically proportion the air and the stack draught to that supply of fuel. The heater has to think of the gas alone and the stack draught and air supply will be maintained automatically. Those two features are of prime importance to any large user of fuel, and dependent on the present furnace practice, a saving of 10 to 50 per cent can be accomplished. That may sound optomistic, but there are cases where such savings have been accomplished; so that the steel industry, with its highly competitive nature, will be forced into the savings which may be accomplished by automatic control on large fuel consumers.

John D. Hiles†: Why is it seemingly impossible for the operator of the open hearth furnace to operate gas as well as air?

W. P. Chandler: He should control his gas to the furnace by hand.

Mr. Hiles: Why not automatically?

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*American Heat Economy Bureau, Pittsburgh, Pa.

†John D. Hiles Co., Oliver Bldg., Pittsburgh, Pa.

W. P. Chandler: The automatic control of fuel supply to any furnace is usually accomplished through temperature control. On small furnaces such as heat treating and annealing furnaces the temperature control is working out nicely, and no doubt in the future it may be applied to open hearth furnaces and large heating furnaces; but at the present time, I do not believe there are many executives who would care to jeopardize the production of an open hearth furnace by operating it with a thermo couple, particularly with the present development in the art.

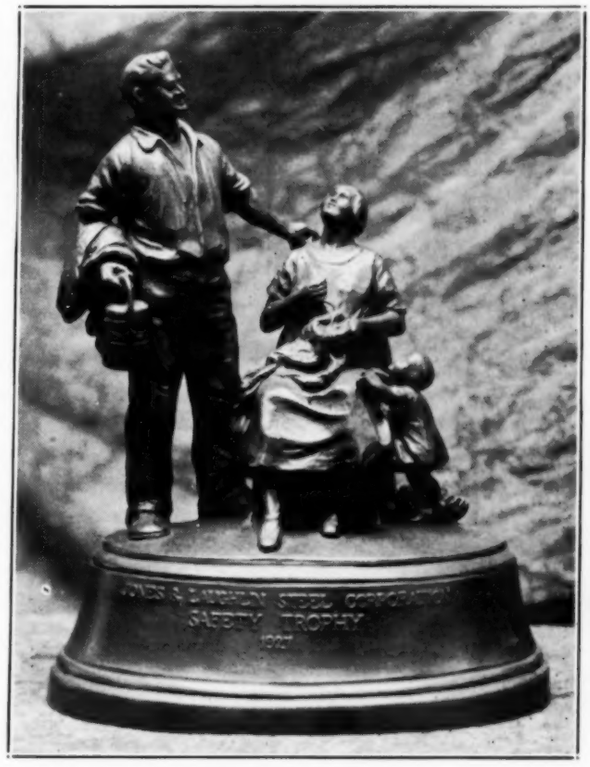
Jones & Laughlin Safety Trophy Award for 1927

AT a meeting in Soldiers' Memorial Hall, Pittsburgh, Pa., Tuesday evening, January 24th, at which 3,000 superintendents, foremen and key men were assembled, 1927 Safety Trophies were awarded to the works and departments of the Jones & Laughlin Steel Corporation having the best accident records for the year.

E. F. Blank, Safety Director for the Corporation, acted as Chairman of the meeting and called attention to the fact that the company had just finished its most successful year in Safety, having had a reduction **in the mills of 57% in Accident Severity, 32% in Accident Frequency and 75% in fatalities over 1926,** which had been the best year for Safety heretofore. The reductions **on the railroads were 82% in Severity, 28% in Frequency and 100% in fatalities over the previous** year.

The inter-works safety trophy for 1927 was won by the South Side Works of the Corporation in a contest, based on Accident Severity, with the North Side and Aliquippa Works. The trophy which is a bronze sculptural group depicting the safe return of a steel worker to his home was presented by R. J. Wysor, General Manager of the Corporation, and accepted by S. S. Marshall, General Superintendent of the South Side Works. This plant, which probably has more inherent hazards than any other plant in the steel industry, went through the year with an average force of 5,000 men without a fatal injury. The South Side Works has operated since April 3, 1926, without a fatality. The annual railroad trophy was won by the Aliquippa & Southern R. R. at Aliquippa, Pa., in a contest with the Monongahela Connecting R. R. in Pittsburgh. The trophy which is a silver loving cup was presented by J. R. Geddes, Superintendent of Railroads, and accepted by Dan O'Connor, Superintendent of the Aliquippa & Southern R. R.

An inter-departmental contest was conducted during the year in each of the three works. The trophies for these contests were bronze tablets suitably inscribed for the occasion. One of these plaques was won by the **By-Product Plant** of the North Side Works, which established a new low Severity rate of .04 for that department. The **Power Department** was the winner at the South Side Works with a **Severity rate of .09.** These tablets were presented to the department superintendents by G. H. McClain, Safety Engineer of the Pittsburgh Works. The North Mills Boiler House was the winning department at the Aliquippa Works and the trophy was awarded to the Boiler House superintendent by Walter C. Titus, Safety Engineer of the Aliquippa



View of Safety Trophy

Works. This department had but one lost time accident during the year and that was but of one day's duration. The **Severity rate the year was .003.**

The chief address of the evening was made by the Honorable C. A. Waters, Secretary of the Department of Labor and Industry of the Commonwealth of Pennsylvania, who congratulated the men on their interest in and success of their accident prevention work.

Relation Between Central Stations and Steel Plants in Connection with Protective Equipment*

By B. M. JONES†

WHEN I first came into contact with steel plants, the thing that impressed me most was the everlasting cry of "Tonnage and more Tonnage," and right along with that cry it was impressed upon me that the protective equipment had a very important bearing upon the tonnage.

Several years ago I was in the steel plant, Engineering Department of the Westinghouse Company, and in making electrical installations in steel plants with the subsequent tests, the electrical departments of the steel plants nearly always called for higher and higher settings on all breakers and overload relays with the resultant heavier and heavier duty on the protective equipment.

The very subject of this paper raises a number of questions in the minds of you steel plant electrical people. The answers to quite a few of these questions are relatively easy, but the answers to some of the others, are somewhat difficult. One of the most important questions is that of the protective equipment necessary to cut out or isolate any equipment that may develop trouble. Most of you steel plant electrical engineers are familiar with your own protective equipment problems and those of you who purchase power from Central Stations, expect the Central Station Engineers to provide adequate protective devices and to keep them in proper operating condition.

I can assure you that the Duquesne Light Company, with whom I am now connected, as well as all other Central Station Companies supplying power to steel plants, take this responsibility very seriously and do their very best to provide the most adequate protective equipment that can be economically justified. Just to illustrate the extent to which we Central Station people go to provide this protective equipment, one large Central Station Company which supplies a considerable number of steel and industrial plants, spent some $300,000 in changing or relocating fifty-three breakers in consumers' plants only, on their 22 Kv. system in 1927. This money was spent purely to provide better protective equipment, as it obviously did not increase the carrying capacity of any equipment.

All of you are familiar with fuses, carbon circuit breakers, oil circuit breakers, relays, lightning arresters and other protective devices, being more familiar with some than with others. We Central Station engineers and operators must of necessity become familiar with all of these devices for we have to use all of them. Sometimes we wish that we did not have to use some of them, as such a time when your steel plant is down and you call up to find out the reason why and we have to say that the lightning arrester did not arrest, and the line burned down—or some similar happening about other equipment.

Sometimes you find aluminum wire used as a fuse, and the protective relay shorted out, and the breaker block closed. We find similar conditions, but fortunately at very rare intervals and we bend every effort to eliminate such troubles. It is the aim of all Central Station Companies to provide the very best in the way of electric service to your steel plants and to keep the protective equipment in the proper operating condition. As our system grows, we must of necessity change our protective equipment to continue to provide this service.

Our Company always investigates, and frequently tests or witnesses tests on the protective equipment before it is purchased. Improvements in the equipment are watched and investigated all the time so that we will be able to provide the best protective equipment at all times. Consumers to whom the Central Station Companies supply power, always want to know how much "kick" will be delivered into their equipment connected to the lines. This is necessary so that they can purchase and install protective devices and other equipment that will withstand this kick.

One of the most important pieces of equipment is the oil circuit breakers, and to purchase the proper equipment, it is necessary to know the amount of short circuit that the Power Company can deliver through the consumers' circuit breaker. Sometimes the consumer's circuit breaker is connected directly to the Power Company's transmission line and other times the consumer's breaker is connected on the low side of the power bank, which bank is connected directly to the power company's transmission line.

It is possible, practical and feasible for the power company to deliver energy to the steel company's plant with approximately the same kick behind it as would be obtained from the steel company's own generating station. This can be accomplished by means of reactors or in case transformer banks are used, having the proper reactance in the transformer banks, or by separating the bus at the customer's plant into the required number of sections to get the desired kick.

Of course, in a case where the steel company's generating station is considerably smaller than the power company's system, the power company can deliver the severer kick for the steel company's generators will begin to lay down immediately upon the establishment of the short circuit. This is of no consequence except in very rare cases and for the same loads the circuit breaker cost would be the same.

The power company's breakers on the line in the power company's station which supplies the

*Presented before Pittsburgh Section, December 17, 1927.

†Equipment and Protection Engr., Duquesne Light Co., Pittsburgh, Pa.

steel plants are purchased on two shot, two minute, O.C.O. cycles, which means that the breaker can interrupt the short circuit on the line once, and then two minutes later can be closed upon the short, and then interrupt it a second time. This provides one trial for re-establishment of service to the steel plant in the hope that the trouble on the line will have been cleared by the first opening of the breaker. Very frequently the capacities for the second short in the breaker permits re-establishment of service at the end of two minutes, whereas the purchase of a smaller breaker would mean a longer interruption to the steel plant until the line and other equipment could be patrolled ot determine whether or not it was safe to close the breaker.

Lightning arresters are used where the steel plants are fed by overhead lines, and the arresters are located at the steel plant to provide protection for the maximum amount of line. In recent years, lightning arresters have been developed to a reasonably satisfactory status for pole top mounting along the overhead line to drain off the lightning charge at several points and thus prevent some of the line troubles due to lightning.

Associated with the circuit breakers on the power company's lines which supply the steel plant, are protective relays which recognize the line trouble and effects the tripping of the circuit breaker. These relays are of various types, such as plunger and induction type with which we are all reasonably familiar, and must be set to isolate the faulty line or equipment immediately, with minimum interference to the remainder of the power company's system and other customers.

Such relays are frequently set at varying time settings in order to provide selection for the other customers, and the time setting of one steel plant is not necessarily the same as another. Being responsible for the protection of our system, I can assure you that we strive diligently to keep the time settings to the minimum that will cut off the equipment, line or customer in trouble without interference to other customers.

The Duquesne Light Company has approximately 45,000 protective relays in service now and they are regularly tested and inspected every six months, and oftener in case difficulties are encountered with them or we are suspicious of their performance. We maintain several crews of highly skilled relay testers with truck trailers, testing transformers and other test equipment, to facilitate the maintenance of these relays. Every relay performance is analyzed thoroughly, and the responsibility of any improper operation charged directly to those responsible for it. I might say here that our relay performance for the month of November was 98½% correct.

The settings of the steel company's relays and breakers in most cases are governed by the maximum settings which the power company can permit without jeopardizing the service to other customers. This of course must govern everything that the power company does, to wit, the greatest good to the greatest number.

Just at the present time the oil circuit breaker is the protective device to which the power companies are giving the most thought. With the increase in generating capacities and the increase in transmission capacities, the short circuit or interrupting duty upon all breakers has been raised steadily, which necessitated the changing or relocating of a great number of breakers, in one case fifty-three (53) breakers at 22 Kv as referred to previously.

Some power companies actually make tests, subjecting the breakers to their interrupting ratings to determine exactly what capacities the breaker can safely interrupt, among them being the Duquesne Light Company and the West Penn Power Company in the Pittsburgh district. These circuit breaker interrupting capacity tests have been very interesting and extremely valuable in determining the purchase of new circuit breakers and have also been of immeasurable benefit to some electrical manufacturers in the improvements and designs of their breakers, for the final proof of the pudding is in the eating, as we all well know.

The inspection and maintenance given to the circuit breakers by the power company is of a very intelligent and high order and involves the regular inspection of the breaker with the testing of the oil to determine whether or not it should be changed. In any case, where a circuit breaker has been called to interrupt any trouble it is immediately given a very thorough inspection and the oil is tested for its dielectric strength; all contacts are cleaned or replaced if necessary, and the oil is replaced if it has carbonized to any material extent.

The settings of the short circuit relays on the protective circuit breakers on the power company's lines is high enough to allow full load on the line with a large momentary overload without interruption, and any disturbance higher than this setting sustained for more than several seconds will trip out this breaker. This is absolutely necessary to prevent interference with other customer's service.

In case the customer's service is protected by a fuse, the fuse is set high enough to provide the same degree of service. In case of a ground on the transmission system, or the equipment connected thereto, this equipment must be isolated immediately even thought the ground current is small compared to the load current. You can readily appreciate that this is necessary to prevent the spread of the trouble and to minimize the damage that will be done. Incidentally, on transmission lines a great portion of the line trouble is caused by grounds rather than short circuits.

And finally, the circuit breakers installed on the steel plant properties as is frequently the case, which are owned by the power company, are given the same care in purchasing and installing as is given to all other breakers on the power company system. The maintenance of these breakers is likewise given the same care and attention as previously described. The setting of the relays of the breakers at the steel plants must be set to select with the other protective devices of the power company's system, and must at the same time provide for the satisfactory operation of the steel plant with the desired relay and breaker settings.

DISCUSSION

A. C. Cummins*: The system with which I am associated does not happen to be connected with any public utility, although of considerable scope in itself.

*Supt. Elec. Dept., Duquesne Works, Carnegie Steel Co., Duquesne, Pa.

One thing I have discovered is that most of us are used to thinking about capacity of oil circuit breakers in respect to their ability to rupture short circuit currents. On the particular system I work with, we discovered that most circuit breakers have ample rupturing capacity, but lack mechanical strength to stand stresses due to initial flow of current at the time of short circuit. I do not know whether this condition is generally manifest throughout the steel industry, but I rather suspect it does, as short circuit current figures in two other large steel plant systems in which breakers have sufficient rupturing capacity, but do not have sufficient mechanical strength to resist initial short circuit currents have come under my observation.

Of course isolated steel mill systems as well as those operating in connection with public utilities, are interested primarily in safeguarding their employees and maintaining 100% continuity of service. We may have breakers ample mechanically and with sufficient rupturing capacity, but if the question of maintaining bus voltage under short circuit conditions is not considered, voltages throughout the system will drop to a point where synchronous apparatus will drop out of step, and serious interruptions in production will occur. This condition led us to make further studies which demonstrated that a judicious use of reactance in feeder circuits was essential in maintaining 100% continuity of service, and was also an asset in relieving circuit breakers of a large majority of conditions which imposed maximum mechanical stresses and short circuits to be ruptured.

Another question that is vital is the matter of maintaining relay settings as originally set. You can devote a great deal of time and thought to providing the correct relay settings, but if those settings are not inspected regularly and maintained in a high order of accuracy, you lose all the advantages gained. In closing I would like to ask Mr. Jones what they feel is the maximum length of time relays can safely be operated in a steel mill system without rechecking time and current settings for accuracy of operation.

B. M. Jones†: Mr. Cummins asked how often the relay settings should be checked? As everybody knows there is a considerable amount of dirt in the steel mill, and there is also a considerable amount of dirt and dust in the substations of our Company in and around the City of Pittsburgh. The Duquesne Light Company now checks their protective relays regularly every six months and oftener if there is any suspicion of trouble with any other protective relays. We are considering making regular tests every four months, and expect to begin this program some time early in 1928. The relays that we rely upon particularly for protective purposes are of the induction types, similar to the Westinghouse type "CO" or the General Electric Company type "IA." Our Company feels that skilled help should be always available for the checking and testing of protective equipment, particularly protective relays.

Mr. Cummins asked about the initial rush of current when a short circuit occurs. This initial rush of current subjects your apparatus to a very severe physical strain, and should be investigated very carefully before purchasing any equipment that may be subjected to the short circuit. The first rush of current is considerably higher than that with the circuit breaker open, and I can best illustrate this by citing some exact figures. In 1926 we were testing the interrupting capacity of 22 kv. oil circuit breakers, and the breaker actually interrupted about 11,000 amperes, but the first rush of current was 33,000 amperes. Obviously, the breaker must stand the physical stresses that will ensue from this 33,000 amperes, as well as being able to interrupt the 11,000 amperes. As Mr. Cummins pointed out, this sudden rush of current is unavoidable, and may necessitate the purchase of considerable more expensive equipment unless means are provided for reducing this initial rush.

†Equipment and Protection Engineer, Duquesne Light Co., Pittsburgh, Pa.

Items of Interest

Radio television leaped the barrier between the laboratory and the home recently in the first demonstration of television broadcasting, arranged by the Radio Corporation of America and the General Electric Company. At three different points in Schenectady, including the home of E. W. Allen, vice president of the General Electric Company, groups of engineers, scientists and newspaper men standing before the first "home television sets" ever to be demonstrated, saw the moving images and heard the voices of a man and a woman transmitted from the research laboratories of the General Electric Company several miles away.

So lifelike were the lights and shadows reproduced from the research studios that the curl of smoke from a cigarette and the flash of an eye were transmitted by radio just as a picture unfolds on a screen.

The first home television set is of very simple construction, not unlike the familiar phonograph cabinet in size and exterior appearance. It was developed by Dr. E. F. W. Alexanderson, consulting engineer of the Radio Corporation of America and the General Electric Company, and by his assistants in the laboratory here.

In this instance the transmission of the moving object was made on 37.8 meters wavelength while the voice was simultaneously sent through the air on 379.5 meters, the normal wavelength of WGY. The receiver which Dr. Alexanderson used differes from the ordinary short wave receiver in that it converts the electro-magnetic wave into light instead of sound and the light becomes an image corresponding in movement to the action of artist at the transmitting end.

"While this is an historical event comparable to the early experiments in sound broadcasting, the greatest significance of the present demonstration," declared David Sarnoff, vice president and general manager of the Radio Corporation of America, "is in the fact that the radio art has bridged the gap between the laboratory and the home. Television has been demonstrated both in this country and abroad prior to this event, but it did not seem possible within so short a time to so simplify the elaborate and costly apparatus of television reception, that the first step might be taken towards the development of television receivers for the home.

"With all that has been accomplished there are still many experimental stages to be passed before a practical television service can be established. The first step contemplated is the placing of laboratory models of the present television receiver at central and strategically located points so that with the aid of technically trained observers, future experiments may be continued not only in the reception of but in the simultaneous transmission both of sight and sound.

"Sound broadcasting has now developed to an art and industry of world wide scope and significance. The television receiver as at present developed will supplement and not replace the modern radio receiving set in the home. Broadcasting television, it seems clear, will develop along parallel lines with broadcasting of sound so that eventually not only sound but also sight through radio broadcasting will be available to every home," Mr. Sarnoff concluded.

The elements of the television home receiver are a light source, the scanning device and the synchronizing system. The signal, or electro-magnetic wave from the television transmitter, is received in equipment designed to receive modulations as high as 40,000 cycles. The amplifier is substantially the same as the amplifier of the home loud speaker. The receiving system differs from a modern loud speaker system in that a neon gas-filled lamp is substituted for the loud speaker. The amplified current is delivered to this lamp, known as the Moore lamp, which responds to the intensities of the current and gives fluctuations of the light intensity just as a diaphragm of the loud speaker reproduces pulsations of the air waves.

The scanning disc is 24 inches in diameter with 48 small holes, each hole 35 mils (.035 inch) in diameter and arranged in a spiral so that each of the 48 holes will follow the others past an aperture and trace successive lines of the picture, completing or literally painting a picture in one revolution. In other words, a ray of light through successive holes traces over the entire object. The disc is revolved by a standard motor, similar to those used in household devices such as the washing machine or vacuum cleaner. The revolutions occur at a speed of 18 per second, slightly faster than a film passes through a motion picture camera. An observer, looking at this revolving disc as the light from the Moore lamp shines through these small holes, would see the image being sent by radio but this picture would be but 1½ inches square.

Magnifying lenses enlarge the picture twice so that it is 3 inches square in the aperture in the front of the receiver cabinet.

Synchronization of the scanning disc of the receiver with the scanning disc of the transmitter is obtained by manually operated control, a push button held in the hand. By means of this button, of the bell ringing type, the picture may be held in the field of vision with a little practice, as naturally after a time as driving an automobile or steering a bicycle.

The reproduced picture or object has a pink color, which is characteristic of the neon gas used in the lamp. D. McFarlan Moore, inventor of the lamp and an engineer at the Edison Lamp works of the General Electric Company, found in early work that this gas was most efficient and most sensitive for reproducing a light which will go on and off in a millionth part of a second.

The transmission system is of the type using a disc with spiral holes, a duplicate of the disc in the receiving machine. A spot of light is projected on the object through the moving disc and the reflection of this light is intercepted by photo electric cells, which convert the light to electric waves, ready for the short wave transmitter.

The increasing use of welding in automobile manufacture is demonstrated by the fact that a large number of parts on the new Ford car are constructed by arc welding. Among these welded parts are the rear axle housing, the steering gear casing, the radius rod, the spare tire carrier, the drag link for the front axle and the axle rods. It is said that experiments are now under way preparatory to welding several other parts in addition to these.

In the past few months the Ford Company has installed approximately 30 General Electric automatic arc welding equipments for this work. Although this is considered a fair sized automatic welding installation, it is understood that it is but a beginning of the automatic arc welding operations planned by the Ford Company.

The Roller-Smith Company, 233 Broadway, New York City, makers of instruments, relays and circuit breakers, announces the following changes in and additions to its sales organization:

Mr. S. H. King has been added to the sales force in New York City and will operate in the Metropolitan District.

Mr. Albert Milmow, Latonia Building, Charlotte, N. C., has been appointed exclusive agent for the States of North and South Carolina.

Mr. M. B. Mathley, Monadnock Building, Chicago, Ill., has been appointed exclusive agent for the Chicago territory, superseding Mr. M. Frankel, who has been representing Roller-Smith in the Chicago territory for many years. Mr. Mathley has been associated with Mr. Frankel during that period.

Mr. W. J. Schuhmann, who has been connected with the New York office of Roller-Smith for many years as a Sales Engineer, has been transferred to the Company's Works at Bethlehem, Pa.

The water works pumping equipment of the City of Haverhill, Mass., is described in a four-page leaflet issued by the De Laval Steam Turbine Co., of Trenton, N. J. The city operates two pumping stations, one at Kenoza, and the other at Millvale, both of which were originally equipped with reci-

procating pumping units. With a view to increasing the water supply and reducing pumping costs, two electric-motor-driven centrifugal pumps have been installed, one having a capacity of a little over 7,000,000 gallons per 24 hours against 90 feet head, and the other a capacity somewhat in excess of 6,000,000 gallons per day against 211 feet head. In the official acceptance tests, these units developed a very high overall efficiency from wire to water.

The Trumbull Electric Manufacturing Company has appointed Mr. Frank M. Buckley as sales representative in the Pittsburgh district, who will work for this year with Mr. A. H. Bergendahl, the present salesman whose home is in Cleveland.

Mr. Buckley is a graduate of Rensselaer Polytechnic Institute, was connected with the Crouse-Hinds Company for some time, and is thoroughly acquainted with electrical procedure.

The Combustion Engineering Corporation has specified a Steere arc welded steel purifier for the new low temperature carbonization plant it is building here. It will be erected in the spring by the Semet-Solvay Engineering Corporation.

The purifier will be 28′x70′x12′6″ in size, and of the elevated type. It will have three compartments and two layers of oxide trays. A gantry crane will handle doors and will also carry an oxide elevator and screw conveyor for filling the box. Spent oxide will be removed through four bottom dump doors under each compartment.

The purifier will be equipped with a 20-inch manifold of Steere welded steel construction and will have 15 Steere gate valves. The capacity will be 4,000,000 cubic feet of gas each 24 hours.

Matthew S. Sloan, president of the Brooklyn Edison Company, speaking before the Committee on Relations with Financial Institutions of the Eastern Geographic Division of the National Electric Light Association at the Ritz Carlton Hotel, Philadelphia, January 18, pointed out the dangers in the Boulder Dam Project.

Mr. Sloan discussed the two measures affecting the public utilities now before Congress.

The public utility industry, according to Mr. Sloan, is not opposed to the proposed Senatorial investigation of gas and electric utilities and their financing. The industry is not afraid of an investigation which is fair and square. The utilities believe that they are doing a good job: they are conducting their business in a manner calculated to serve the best interests of the public as well as of the industry, and they are constantly subject to official supervision and regulation; the utilities have nothing to hide.

The Boulder Dam Project as contemplated in the Swing-Johnson bills before Congress, however, involves the entrance of the government into the power business, and to this the utilities are definitely opposed. The speaker called attention to fallacies in the argument that the sale of the electric power developed at the Dam by the government, in competition with the cheap steam generated electric power already available in the neighboring cities, would pay for the Project, and he questioned both the practicability and the necessity of the Project as at present formulated.

He claimed that the water power of the Colorado River could be developed to the best advantage of both the government and the electric industry, under the existing federal water power act.

Mr. Sloan closed by affirming his belief that the innate honesty and strong common sense of the American people would prevail, and that the ultimate decision in the Boulder Dam matter would be based on the fundamental facts in the situation.

An announcement has recently been made by the officials of The Timken Roller Bearing Company that an expenditure of $4,000,000 to be devoted to increasing the production facilities of the Company has been authorized for the coming year. The greater part of this expansion program concerns the Company's plant at Canton, where both the steel mill and the bearing manufacturing plant proper will be considerably enlarged. Among other features a new sub-station of greater kilowatt capacity will be built for supplying electric power for both the steel mill and the factory.

The half-yard excavator brought out by Harnischfeger Corporation early in 1927 met with a wide spread demand. Large General Contractors such as Booth & Flinn, Inc. of Pittsburgh, Pa., as well as small excavating contractors throughout the country have found numerous uses for the P&H Groundhog.

When the new machine was first placed on the market Harnischfeger Corporation anticipated that shovel, dragline, clam-shell, and pile driver attachments would meet all requirements, in the half-yard size. However, trench hoes and skimmer scoops were soon being called for, and in response to this demand the manufacturer designed two additional attachments.

The hoe and skimmer booms are built up of heavy I beams—securely trussed and braced. All joints are electrically welded to provide the maximum rigidity and strength.

The hoe can dig to a depth of 16 feet. By shifting the course of the boom and bucket any width of trench can be cut. The hoe dipper is shaped from heavy boiler plate and the seams are electrically welded.

The skimmer bucket is constructed of heavy boiler plate and has a horizontal travel of 13 feet. Heavy spring bumpers are cast integral with the boom foot, thereby eliminating heavy jolts on the boom as bucket rolls back to the machine.

All five P&H models are convertible for use as shovel, dragline, trench hoe, skimmer scoop, clam-shell, pile driver, etc., by a simple change of booms or attachments. It is never necessary to change the drum, as a special patented spider is permanently installed on the power drum. The laggings required for various classes of work are split in two sections and can be quickly bolted to the drum spider. All wear consequently develops on the inexpensive laggings and not on the drum.

A new bulletin has just been received from the printer, which completely describes the P&H half-yard excavator with all attachments.

Allis-Chalmers Mfg. Co., Milwaukee, has opened a new district sales office at Phoenix, Arizona, covering the States of Arizona, New Mexico and Northern part of the Republic of Mexico. The

office is located at "308 Heard Building," with J. B. Cooper as manager. Mr. Cooper's headquarters were formerly in Los Angeles.

A branch office has been opened at San Antonio, Texas, 619 Frost National Bank Building, with Mr. Earle R. Hury in charge. This is a branch of the district office at Dallas.

A branch office is also being opened at Grand Rapids, Michigan, Weiss Service Building, with G. C. Culver in charge. This is a branch of the Detroit District Office.

The Fawcus Machine Co., of Pittsburgh, Pa., has recently placed on the market a new patented type of worm reduction gear especially designed to give high ratios of speed reduction with better efficiency characteristics than are usually possible in worm gears where the ratios are so great. The units comprising the complete line, which is known under the type designation of W T H have been built in three sizes, Nos. 5, 6 and 7, with capacities of 15, 20 and 35 HP., with corresponding ratios of 98:1, 190:1 and 160:1, respectively . The actual speeds of the different units are, 900/4.4 R.P.M.; 1150/6 R.P.M., and 1150/7.2 R.P.M. The units have a common efficiency, about 75 per cent under the above load conditions. They are suitable for any sort of slow speed, heavy duty application that comes within the limit of their horsepower range. The horsepower ratios and speeds given are only illustrative, as the ratio can be varied up or down 50 to 300 to 1, with corresponding inverse horsepower variations.

The essentials in design and construction are uniform throughout the whole line, being substantially as follows. The driving motor is connected by means of a flexible coupling to a helical pinion which drives a helical gear mounted on an extension of the worm shaft. This gear drives the worm, which in turn drives the worm wheel. By this interposing the helical gear train between the motor and the worm shaft it is possible to hold the tooth angle on the latter within the limits that will give the best efficiency, and still obtain a high reduction ratio. Another feature that aids in obtaining a high degree of efficiency is the fact that all the various shafts are mounted in Timken Bearings. The helical pinion shaft mounting comprises two bearings, one at each end of the shaft, and the same arrangement is used for the worm wheel. The worm shaft is mounted on two steep angle bearings, one located at the end opposite to the helical gear, and the other between the worm screw and the gear. The latter bearing has been selected as being of sufficient capacity to carry the overhanging load of the helical gear in addition to the normal loads imposed by the worm thrust.

The gear reduction unit and the driving motor are mounted on a heavy semi-steel unit base, provided with six lugs which permit its being firmly bolted to the floor, or foundation. The gear unit proper is enclosed in a two piece semi-steel case braced for rigidity and strength, and firmly bolted to the common base. The case is split on the worm wheel horizontal center line, facilitating assembly, and permitting access to the worm wheel and worm shaft. A hand hole is provided to permit inspection of the helical gear and pinion. The bottom of the case forms the oil reservoir, the proper level being indicated by a line cast into the case, level with the filling plug. Thus any danger of over-oiling is eliminated. Drain plugs and oil level plugs are provided on both sides, so that one is always easily accessible irrespective of how the unit may be mounted.

The helical pinion is forged integral with its shaft, as is the worm and its shaft. The worm wheel is made of specially hard phosphor bronze, being ground together with the worm in a specially built machine so that its center distance is brought to the exact distance required by the housing in which the gears are to be run. All shafts are of high carbon steel double case hardened and ground true to size. The bearing fits in all cases are ground to size after hardening to insure true running and proper alignment at all times. Both gears and bearings are self lubricated from the oil reservoir in the bottom of the case. The bearings are carefully adjusted at the factory, so that there is no necessity for disturbing them after the unit is installed.

The Trumbull-Vanderpoel Elec. Mfg. Co., manufacturers of T. V. Safety Switches announce the appointment of Mr. Wallace L. Fleming as their District Representative with headquarters in Chicago.

The Air Reduction Co., Inc., 342 Madison Ave., New York, has acquired the assets and business of the Carolina Standard Gas Products Company, with an oxygen plant at Charlotte, North Carolina. The Air Reduction Sales Company now has the production and distribution facilities of 36 oxygen plants and 20 acetylene plants. These with warehouses give the company a total of 110 distributing points for oxy-acetylene gases, equipment and supplies.

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF

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Names and addresses of stockholders holding 1 per cent or more of total amount of stock: None.

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JOHN R. DOYLE, Asst. Editor.

Sworn to and subscribed before me this 20th day of September, 1927.

LEAH H. RUGG, Notary Public.

(My commission expires January 20th, 1930.)

Fin Furnaces Predominate

FURNACE AND DRAFT PRACTICE

NAME OF STATION	FUEL: KIND & B.T.U. AVE	FUEL: METHOD OF FIRING	FURN. VOL. CU. FT. PER SQ. FT. B.H.S.	HEAT LIBERATED BTU PER CU. FT. PER HR.	CORRESPONDING BOILER RATING	AIR PRENTR. TYPE & SQ. FT.	ARE ECON. INSTALLED	TYPE	WALL SURF. SQ. FT. PER B.H.P.	EARTH SCREEN SURF. SQ. FT.	FANS: CAPA. C.F.M. F.D.	FANS: CAPA. C.F.M. I.D.	FANS: DRIVE F.D.	FANS: DRIVE I.D.	FANS: SPEED R.P.M. F.D.	FANS: SPEED R.P.M. I.D.	FANS: STAT. PR. IN. H2O F.D.	FANS: STAT. PR. IN. H2O I.D.	CHIMNEY HEIGHT - NO. BOILERS PER STACK
LAKESIDE	WVA 12,800	PC SUSPENS.	1.05	10,500	300%	PLATE 61,300	NO	FRONT WALL FIN TUBES & SIDE W. 1000 # SUPERHTR. REAR W. - 300# REHEATER	1.45	5.34	2 @ 42,000	2 @ 77,500	MOTOR		850	575	3.5	6.5	2 @ 280
BAYSIDE	YOUGHIOGH. 13,500	P.C.	0.81	ABOUT 20,000	210,000 LB./HR. 350%	ROTARY ELEM. 110,000 LB./HR.	HEATER SEC. IN BOILER	NO. 1 - FIN TUBES NO. 2 PROTECTED TUB	1.96 1.29	NONE	2 @ 70,000 LB./HR.	2 @	MOTOR-DRIVEN AIR PRENTR. F.	VARIABLE	MAX 1800		4.2		2 @ 100
STANTON	BATH. COLM. 10,800	CH. GRAT STOKERS	0.439	NOT AVAILABLE		ROTARY EL. 40,500	YES AIR-WATER	"STANDARD REFRACTORY" AIR COOLED THROAT			2 @ 33,000								
EAST RIVER	POCAHONTAS 14,000	P.C. IN SUSP	1.075	14,000	500	STA. PLATE 28,400	NO	FIN TUBE WATER COOLED	3.57	5.60	1 @ 60,000								
MORRELL ST.	WVA. BIT. 13,800	P.C. SUSP.	1.49	14,000	390	PLATE 10,980	YES 1/2 TUBES LEAD COATED	RAD. SUPERHTR. FIN TUBES VENT FRONT WALL	2.76	4.83	1 @ 64,000								
DES MOINES	IOWA 9,100	CHAIN GRATE	0.41	NOT AVAILABLE		PLATE 12,420	YES	FIN TUBES WATER COOLED SIDE WALLS	3.10	NONE	1 @ 78,000								
BUCK	COAL 13,000	SUSP.	1.07	"	"	PLATE 232 ELEMENTS	NO	FIN TUBE WATER COOLED	2.58	NOT AVAILABLE	2 @ 52,500								
WHIPPANY	PA. ANTHR. & BUCKWHT. 12,000	CHAIN GRATE	0.203	"	"	PLATE 5170	YES	REFRACTORY AIR COOLED			1 @ 45,000								
LAUDERDALE	FUEL OIL		0.896			ROT. EL. 82,000	NO	FIN TUBES WATER COOLED	2.85	3.38	1 @								
HARBOR POINT	COAL 14,000	U-FEED STOKERS	0.425	20,280	280	NONE	NO	F TUBE SIDE-WATER BACK IN BOIDE W. AIR COOLED FRONT	2.500		1 @ 120,000								
NECHES	N. GAS 960 B.T.U. FUEL OIL 18,000 LB.	SUSP.	0.526			FUTURE	NO	PROTECTED WATER TUBES AIR COOLED FRONT WALL	1.40	PROT. TUB FORM FLOOR SEE DWG.	2 @ 80,000								
KIPS BAY	W.VA. AND SPOT PIKE 14,500		1.3	22,000	325,000 TO 450,000 LB./HR.	PLATE 50,000	YES	WATER COOLED FIN TUBES	2.44	6.86	2 @ 200,000								
BEACON ST.	W.VA. & KY. & OHIO 13,500	U-FEED STOKERS	0.48				NO	NONE			1 @ 50,000								
MINNEQUA	COLO. SLACK 12,000 B.T.U. 65.4%	SUSP.	0.6		NORMAL 150 200 MAX. 300	NONE	NO	REFRACTORY			3 UNITS 25,000 FOR PR								
MASSILLON	B.P. GAS COAL 12,000	SUSP. STOKERS	0.73	19,000 MAX.	336 MAX.	BOILER SIDE WALLS	INTEGRAL WITH BOILERS	AIR COOLED WITH WATER SCREEN		2.35	2 @ 89,000								
THREE RIVERS	NOVA SC. 28.4% SLUDGE	P.C. IN SUSP.	0.80		300 MAX.	PLATE 5,363	NO	FIN TUBE W. COOLED AIR COOLED FRONT WALL	1.20		1 @ 85,000								

View of section of C-E Fin Furnace Wall from inside of furnace. The tubes are bent out through the walls at top and bottom where they are rolled into headers located outside of the walls.

THIS table is reproduced from an article "Furnace Design and Performance Improves," in a recent issue of Power Plant Engineering. Sixteen modern stations are listed. In eleven plants the furnaces are water-cooled, —*and, in ten of these eleven, C-E Fin Tube Furnace Walls are installed.*

A new booklet illustrating and describing the C-E Fin Furnace will be sent upon request.

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